NONLINEAR IMPACT OF EXTERNAL DEBT ON ECONOMIC GROWTH: THE CASE OF POST-SOVIET COUNTRIES

by

Demchuk Oleksandr

A thesis submitted in partial fulfillment of
the requirements for the degree of

Master of Arts in Economics

National University of "Kyiv-Mohyla Academy"
Economics Education and Research Consortium
Master's Program in Economics

2003

Approved by ____
Ms.Svitlana Budagovska (Head of the State Examination Committee)

____

____

____

Program Authorized
to Offer Degree Master's Program in Economics, NaUKMA

Date ____

National University of "Kyiv-Mohyla Academy"

Abstract

NONLINEAR IMPACT OF EXTERNAL DEBT ON ECONOMIC GROWTH: THE CASE OF POST-SOVIET COUNTRIES

by Demchuk Oleksandr

Head of the State Examination Committee: Ms.Svitlana Budagovska,
Economist, World Bank of Ukraine

In our study we investigate the impact of external debt on economic growth in transitional countries. Recent economic literature, both theoretical and empirical, has devoted great attention to this question. Empirical studies on developing countries have not come to a definite conclusion on this issue. Even though different hypotheses about the role of external debt were tested with the data on developing countries, there was not any relevant empirical research on transition countries so far. A quick accumulation of external debt from the very beginning of the transitional phase explains the importance of establishing research on this question. We use panel data on the 21 transition economies for period of 1994-1999. Our results indicate that the influence of external debt on economic growth in transitional countries exhibits inverted U-shaped curve. We identified the range for indicator of debt to GDP ratio at which, ceteris paribus, economic growth can be maximized. In addition, we found that investments and size of the government positively affect the economic growth in transitional countries.

TABLE OF CONTENTS

List of Figures ii
List of Tables iii
Acknowledgements v
Glossary vi

CHAPTER1.Introduction 1

CHAPTER 2: Literature review and theoretical consideration of debt in the context of economic growth 4
CHAPTER 3: Theoretical Framework 11
CHAPTER 4:Empirical analysis. 16
  4.1.The Econometric Model. 16
  4.2.The Econometric methodology 18
  4.3. Variable Consideration 20
  4.4. Data Description 23
CHAPTER 5:Model Estimation. 25
CHAPTER 6:Conclusions and Policy Implication. 34

BIBLIOGRAPHY 37

Appendices (A-X) 40

LIST OF FIGURES

Figure 1. Debt Laffer Curve 6

Figure 2. Indeterminacy Area of the Growth 13

Figure 3. External Debt to GDP development in Ukraine during transition time 41

Figure 4. Progress of the average Debt to GDP Indicator in transition countries 41

Figure 5. Stylized shape of the non-linear relation between External Debt to GDP and growth 42

Figure 6. External Debt over GDP versus real GDP per capita growth in transition countries 43

Figure 7.1. Stylized shape of the non-linear relation between External Debt to GDP and growth in transition countries 43

Figure 7.2. External Debt over GDP (%) in Transition countries during transition time 44

Figure 8. External Debt over GDP (%) in Transition countries during transition time (separately for each country) 46

LIST OF TABLES

Table 1. Expected signs of the variables. 22

Table 2. Summary Statistics 45

Table 3. Pooled regression for quadratic specification. 49

Table 4. Growth regressions with quadratic specification with investment rate, without time dummy (Panel for the whole sample). 50

Table 5. Instruments for Investment Rate 51

Table 6. Instruments for Debt over GDP 51

Table 7. Growth regression with quadratic specification (Instrumental Variable Regression) 52

Table 8. Growth regressions with quadratic specification with investment rate, with time dummy (Panel for the whole sample) 53

Table 9. Growth regressions with quadratic specification without investment rate, without time dummy (Panel for the whole sample) 54

Table 10. Growth regressions with quadratic specification without investment rate, with time dummy (Panel for the whole sample) 55

Table 11. Growth regression with quadratic specification with investment rate without time dummy (Panel for the former USSR republics) 56

Table 12. Growth regression with quadratic specification with investment rate, with time dummy (Panel for the former USSR republics) 57

LIST OF TABLES

Table 13. Growth regression with quadratic specification without investment rate, without time dummy (Panel for the former USSR republics) 58

Table 14. Growth regression with quadratic specification without investment rate, with time dummy (Panel for the former USSR republics) 59

Table 15. Growth regressions with quintile specification, with time dummy (Panel for the whole sample).. 60

Table 16. Growth regressions with quintile specification without investment rate, with time dummy (Panel for the whole sample) 61

Table 17. Correspondence of the 2002 Liberalization Index Components with EBRD Report Indicators.. 62

Table 18. Tabulated main results from different growth specifications 63

ACKNOWLEDGMENTS

I want to express my wholehearted appreciation to my supervisor Dr. Lilia Maliar for her inestimable and continuous supervision in writing the thesis. I am also grateful to Prof. Coupe for his valuable comments and suggestions. I thank my fellows Uladzimir Hryniuk for invaluable assistance in collecting data. I fail words to express my thanks to Eugen Dubogryz, Ruslan Stepovyk and Vadym Yepishov and for valuable suggestions. I want to say especial thanks to my beloved wife for her enduring all of the rigours of my studying at EERC.

GLOSSARY

Total external debt. It is debt owed to non-residents repayable in foreign currency, goods, or services. Total external debt is the sum of public, publicly guaranteed, and private non-guaranteed long-term debt, use of IMF credit, and short-term debt. Short-term debt includes all debt having an original maturity of one year or less and interest in arrears on long-term debt.

Long-term external debt. Debt that has an original or extended maturity of more that one year.

Public (sovereign) debt. It is the external obligation of a private debtor, including the national government, a political subdivision, and autonomous public bodies.

Short-term external debt. Debt that has an original maturity of one year or less.

Openness index. It is the sum of exports and imports of goods and services measured as a share of gross domestic product.

Chapter 1

INTRODUCTION

Starting from the early 90s countries of former Soviet Union and some other countries from Central Eastern Europe started their transition. In order to make the first steps towards becoming a market economy and as a consequence of their initially distorted economies with the prior communist era they had to engage in large scale borrowing from abroad to finance their budget deficits and to cover a lack of domestic investment. As a result of turbulent time, these countries began to suffer from an increase in indebtness. Only very few countries started their transition with quite high debt stock. Such countries as Hungary, Yugoslavia, Poland, Bulgaria and Soviet Union had heavily borrowed from the West during the communist era and by 1989 had accumulated large external public debt stocks relative to GDP and exports. With the break up of USSR in 1991 Russia proposed the other former Soviet republics the chance to begin their transition without any external indebtness. Russia proposed to take all the debt of the former USSR in exchange for the option that other republics would assign all their rights to the external assets of the Soviet Union. After this agreement all of the former republics of Soviet Union start their new phase of history free of external debt. At the same time, some of the Eastern Central Europe countries were not so lucky. While some of the countries which were heavily indebted at the very beginning of their transition significantly reduced the stock of debt, others which began with free of debt option have accumulated pretty high debt stocks to such an extent that those stocks may be considered in the nearest future being unsustainable.

In the second half of the 1990s, the high external indebtedness of transitional countries has received a lot of attention from both policymakers and the public opinion in these countries (a large amount of attention from citizens and media was devoted to an initiative to reduce debt while policymakers try to meet the conditions of the lenders to receive additional credits). Most of these countries have received very large amounts of loans over the past decades, often at concessional interest rates. But it is quite clear that repayment of the remaining net present value of these obligations would be likely to severely constrain the economic performance of the debtor countries. In addition, further credits (usually to repay old credits) can be given to countries that meet specific policy and performance criteria, which not always seems to be good for countries' further growth[1].

Despite the importance of this research question, there have not been any studies that have addressed it for the transition economies. All studies, which investigate the relationship between debt and growth analysed the situation in developing countries, e.g., Mankew, Romer and Weil (1992) [2]

The goal of the paper

In this study we investigate the relationship between external debt and economic growth using a panel data of transition countries.

Particularly, the question of interest is whether there is any evidence on nonlinear impact of external debt on economic growth in transitional economies. It is interesting to find out at what level of external debt there will be a negative impact on the economic performance and how big this impact will be.

---

[1]The East Asia crisis (1997) can serve as a good example of following such policies without any consideration.

[2] The reason is that there was not very high level of indebtness of transition countries in early 1990`s.

In addition, it is important to detect what the channels are through which the impact is likely to occur.

We use an econometric model of the influence of debt on growth within the standard growth model. As a starting point, we used the model developed by Pattillo et al (2002) for developing countries. As transitional countries have experienced processes different from those in developing countries, we introduced some additional variables as growth determinants which were detected in the growth literature as important ones. This study is based on the analysis of the panel data for 21 transition countries over the period 1993 to 1999.

Structure of the paper

The paper is organized in the following way. Chapter 1 contains the literature review of the main underlying theory, which concerns the debt and growth relationship. Different models and empirical findings are presented briefly; particular attention is given to literature which predicts non-linear effect of debt on growth.

Chapter 3 presents the theoretical model developed by Calvo (1998), which implies a non-linear relationship between debt and growth. In Chapter 4, we provide justification for modifying initial specification of econometrical model in order to mirror more closely the processes that took the place in those economies. Empirical results are contained in Chapter 5 in form of regression analysis of influence of external debt on economic performance in transition countries. Chapter 6 includes our main conclusions and about policy implications.

Chapter 2

LITERATURE REVIEW AND THEORETICAL CONSIDERATION OF DEBT IN THE CONTEXT OF ECONOMIC GROWTH

Many empirical studies have been done in order to find out the nature of the impact of different factors on economic growth and there exist a huge amount of theoretical literature about this issue. Even though the growth literature covers many factors, which can explain different aspects of growth, the issue of the nonlinear impact of debt on growth is not well explored in theoretical models. The existing literature on growth theory related to the topic can be divided into three groups. A First group of theories relates reasonable debt levels to positive effects on growth; a second group of theories relates high accumulated debt levels to negative impact on growth (low growth), and third group of theories combines those two effects and argues that the impact of debt on growth is nonlinear by nature.

The first group can be represented both by early post-Keynesian models and by neoclassical models. The early post-Keynesian models of growth, such as the Harrod-Domar model (1939, 1946) and neoclassical growth models, such as the Solow-Swan model (1956), have emphasized the importance of savings and investment in furthering growth. In the traditional neoclassical growth models assumption about capital mobility or ability of a country to lend or borrow increases transitional growth. This can be explained by the fact that in capital scarce countries the marginal productivity of capital exceeds the world interest rate on capital.

Theories of the second group can be portrayed by the well-known debt overhang theories. According to Claessens et al (1996), the debt overhang theory

"…*is based on the premise that if debt will exceed the country's repayment ability with some probability in the future, expected debt service is likely to be an increasing function of the country's output level*[3]. *Thus some of the returns from investing in the domestic economy are effectively 'taxed' away by existing foreign creditors and investment by domestic and new foreign investors are discouraged*".

Krugman (1998) constructed a model of debt overhang in which he considers the dilemma of debt repayment from creditors' point of view[4]. He argues that a country has debt problems when its own discounted value of all future resource transfers is less than the present value of debt. Facing these problems, the creditors try to find such a strategy, which would maximize the present value of the debt. This strategy takes into account the tradeoff between debt forgiveness and further financing of the country so that the present value of the debt should be comparable with the present value of the future countries` earnings. This, in turn, will imply that the returns from investments in the country will face a high marginal tax demanded by creditors, which will encourage low level of current and future investments[5]. Even though Krugman did not analyze explicitly the impact of debt on growth, the preceding consideration should mean that high indebtness would lower growth through decrease in the level of investments.

Sachs (1989) has raised another theoretical issue; he introduced the concept of a debt Laffer curve through the theory of debt overhang. This curve reflects a

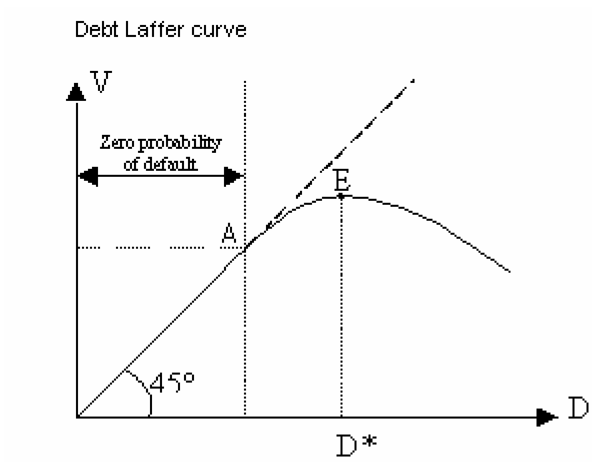
---

[3] Definition of debt overhang as discussed by Claessens et al (1996; p.17).

[4] Debt overhang means the presence of an existing "inherited" debt sufficiently large that creditors do not expect with confidence to be repaid (Krugman 1998).

[5] The debt overhang models argue that if there is some likelihood that in the future debt will be larger than the country's repayment ability, then expected debt service will be an increasing function of the country's output level (Pattillo et al. 2002).

situation when high debt levels result in efficiency losses. Among other factors which impose efficiency losses he mentioned the heavy (marginal) tax debt which can be imposed on future returns to current investments, which would give rise to disincentives for fiscal adjustments and investments, and favour current consumption.



[6]Along the left, side of the curve, increases in the face value of the debt service are associated with increases in expected resource transfer, while increases in the face value (value beyond point E) lower expected repayment on the right side of the curve. Additional amounts of debt actually decrease expected payments. At that stage, a country is said to be on the wrong side of the debt Laffer curve.

The theoretical model developed by Calvo (1998) can be ascribed to the third group of models. His model encounters three distinct debt areas: in the first area, growth is an increasing function of the debt; the second area is an intermediate region where economy can exhibit either high or low growth path and third area where growth is a decreasing function of the debt.

[6] This picture was taken from Sachs (1989)

Calvo (1998) showed that in the area of indeterminacy high level of initial debt would be associated with high tax burden in order to service the debt and, consequently, a lower rate of return on the investment will result. At the same time, high economic growth reduces the tax rate needed to service the debt[7]. In case the critical value of debt is exceeded, the economy settles in the region of low growth. If the economy grows lower than debt itself, the tax burden will become high and the rate of capital accumulation will become low as well, which in turn gives rise to low growth. At the same time, if the economy is in the indeterminacy region a relatively modest cut in debt can lead to the high growth equilibrium; Calvo supposed that even an optimistic private sector can lead to the same result if it invests more than before[8]. He also considered the problem of regulation of capital movement through capital controls, showing that this measure can bring on economy to the high growth equilibrium.

Pattillo et al. (2002) suggested that the Debt Laffer curve could be translated into a Laffer curve for the effect of debt on growth, even though the debt overhang theory did not explicitly trace this effect. They support this suggestion in the following way:

"*Since the peak of the curve is the point where large debt stock begins acting as a steep marginal tax on investment, policy reforms or other activities that require up-front costs in exchange for future benefits, this may relate to the point at which debt begins to have a negative marginal impact on growth. … To the extent that the high debt serves as a tax hindering policy reforms, the resulting distorted macroeconomic environment is likely to contribute to lower investment efficiency and productivity*".

---

[7] This happens because the higher economic growth, the more the country earns and consequently the lower is a tax rate is needed to repay debt.

[8] These considerations concern the cases when the debt level is very close to the critical points; in the first case this is the point between the high growth region and indeterminacy region while in the second case it is the point between indeterminacy region and low growth region.

Cohen and Sachs (1986) presented an endogenous growth model where growth depends only on capital accumulation. The model was constructed to analyze debt repudiation, where creditors face the choice between debt rationing and further lending. The authors show that the equilibrium strategy of competitive lenders is to make the growth of the foreign debt conditional on the growth of the borrowing country. The reason behind this strategy is that creditors should take care to avoid that the country might choose to default as too fast growth of capital accumulation in the early stages may lead to the situation when post-default utility of the country can exceed its value before default and can be counterproductive to the creditors. *The economy, in that case, follows a two-stage pattern of growth.* During the first stage, there is unconstrained borrowing with rising external-debt-to-GDP ratio and with the rate of GDP growth falling progressively; during the second stage, growth of GDP is low, constant and there is constrained (rationed) borrowing[9] (Cohen and Sachs, 1986). Even in the second stage the borrowing[10] of the country is limited because of the risk of repudiation, country's growth can be higher than under financial autarky[11].

The repayment stage does not crowd out investments, but rather induce lenders to choose an investment rate that is higher than the rate that would be chosen by a country under financial autarky. The logic is that lenders are more patient than the debtor is and consequently value growth more than the country itself (Cohen, 1995). As Cohen pointed out this result could depend only on the ability of the lenders to implement an optimal rescheduling scheme. In the case of failure the debt overhang scenario will occur and investments and growth in later stages will be even lower than under financial autarky.

---

[9] The debt grows faster than economy in the first stage, while in the second stage both economy and debt grow at the same rate.

[10] Country only limited but not refused until its benefits from default exceeds benefits from the debt repayment.

[11] Financial autarky is the situation when there is no possibility for country to borrow or lend.

Other channels through which the need to service a large amount of external obligations can affect economic performance include the 'crowding out' effect, the lack of access to international financial markets and the effects of the stock of debt on the general level of uncertainty in the economy. In the crowding out effect, a reduction in the current debt service should lead to an increase in current investment for any given level of future indebtedness. If a greater portion of export revenue is used to service external debt, very little is available for investment and growth (Were, 1996).

During the last decade the empirical literature has grown extremely large, some of the papers found negative impact of debt on growth[12]. So far, only three papers were related to the nonlinear effects of debt on growth.

One of the first studies, which considered the nonlinear effects of debt on growth, was the study conducted by Elbadawi et al. (1997). In the growth regression, the debt to GDP ratio entered both in linear and quadratic form. They found that the debt over GDP ratio at which its positive impact was at the maximum corresponded to 97 percent.

Cohen (1997) conducted an empirical study in which he investigated the failure of standard growth equations to account for Latin American and African slow growth. Running different regressions he found that the variable which represented the probability of the risk of debt rescheduling (debt crisis) can explain low growth.[13] This probability was found to depend positively on the external indebtness. In addition, Cohen found ratios above which the probability of rescheduling becomes very high: a debt to GDP ratio of 50 percent, and a debt to export ratio of 200 percent. In addition, Cohen found that low growth was explained not solely by the standard growth regressions and the probability of rescheduling, but rather by the standard growth regressions and probability of

---

[12]The authors of those papers used linear regression models to investigate the impact of debt on growth.

[13] This variable had negative relationship with growth, i.e. the more the risk of rescheduling, the less the further growth.

rescheduling in conjunction with exchange rate mismanagement (which hurt trade and investments).

Another more recent empirical paper (Pattillo et al., 2002) assessed the nonlinear impact of external debt on growth using panel data set of 93 developing countries over 1969-98. They used different methodologies (OLS, instrumental variables, fixed effects, and system-GMM)[14], a variety of specifications as well as different debt indicators. They found an unambiguous nonlinear debt effect on growth: the average impact of debt on per capita growth appeared to become negative for the debt levels above 160-170 percent of export and 5-90 percent of GDP, which is a much lower level than that found by Elbadawi et al. (1997). Their results suggest that the marginal impact of the debt becomes negative at lower debt levels, about half of those which were found by Elbadawi et al. (1997), while the growth effect is still positive at much lower levels. The authors found that for the average country in the sample doubling the debt slows growth by about half a percentage point per year. The most interesting result is that

"*…the level of investments does not appear to be the main channel through which excessive external indebtness reduces growth. … If we exclude the investments from regression the results are similar, although in some cases the debt coefficient becomes larger, suggesting that only a small part of the impact of debt on growth if through debt contributing to lower investment levels. The result that most of* *the impact is via the quality rather than the level of investment* *is consistent with other empirical studies…*"

The authors suggested that one of the causes is that the prospects of the future tax burden enforce investments asymmetry toward the short-run projects with less positive impact on the long-run productivity growth.

[14] For the purpose of examining robustness of the results they used different methodologies.

Chapter 2

THEORETICAL FRAMEWORK

First, let us consider a simple model of economy developed by Calvo, which predicts the non-linear effect of debt on growth (Calvo, 1998).

The economy produces output only by means of physical capital, K, according to the following production function:

$Q_t = \alpha * K_t$ (1)

So that 1/α unit of capital can produce 1 unit of output. K_0 is assumed to be equal to 1. Capital is assumed to be perfectly internationally mobile ex ante but not ex post, after installation. The economy is assumed to be represented by one representative firm. The net cash flow, S, for a firm that accumulates capital at the rate $\dot{K}$ is assumed to be expressed as:

$$S_t = \alpha(1-\tau)K_t - \dot{K}_t, \qquad (2)$$

where τ, $0 \le \tau \le 1$, is the output tax rate which is assumed to be constant over time. In addition, model assumes that there is no capital depreciation. The net present value of the firm at time zero, V, is given by:

$$V = \int_0^\infty S_t e^{-rt} dt, \qquad (3)$$

where r is the international interest rate which is assumed to be equal to the own-rate of return on output. Going further and setting $z \equiv \dot{K} / K$ [15] we get:

[15] According to the assumed production function the growth rate of the capital is equal to the growth rate of the output*.

$$V = \int_0^{\infty} \left[\alpha(1-\tau) - z_t\right] e^{-\int_0^t (r_s - z_s) ds} dt \qquad (4)$$

As firm is assumed to be a rational agent of the economy it must maximize its value by choosing a non-negative growth path $z(\bullet)$. In order to keep the simplicity of the model it is assumed further that $z = const$ and $z < r$; in this case the equation (4) has at least one solution. According to the latest assumptions the equation (4) takes the following form[16]:

$$V = \frac{\alpha(1-\tau) - z}{r - z} \qquad (5)^*$$

As the firm maximizes its value, farther, differentiating equation (5) with respect to z and taking into account our assumption about non-negative growth path of z, we get:

$$\operatorname{sgn} \frac{\partial V}{\partial z} = \operatorname{sgn}\left[\alpha(1-\tau) - r\right] \qquad (6)^*$$

From this equation, we can notice that if the marginal net productivity of capital exceeds the real interest rate, the optimal choice for the firm is to grow as fast as possible. So in order to prevent an unbounded growth, it must be assumed the upper bound for the growth rate z denoting it by $\bar{z}$. If the marginal net productivity of capital is less than r the optimal choice for the firm is to keep the growth at the minimum level, where $z = 0$. Going further and assuming that economy has as initial debt equal to D, government has full access to international credit markets and that government imposes such tax rate, which would allow just repaying the debt. Therefore, we can get the following expression:

$$D = \alpha\tau \int_0^{\infty} K_t e^{-rt} dt = \frac{\alpha\tau}{r - z} \qquad (7)^*$$

16 All needed intermediate steps are shown in the mathematical appendix and denoted with star "*".

Further, using Equation (7) and (6) we get one of the most important relationships:

$$\operatorname{sgn}\frac{\partial V}{\partial z} = \operatorname{sgn}[\alpha - D(r-z) - r] \qquad (8)^*$$

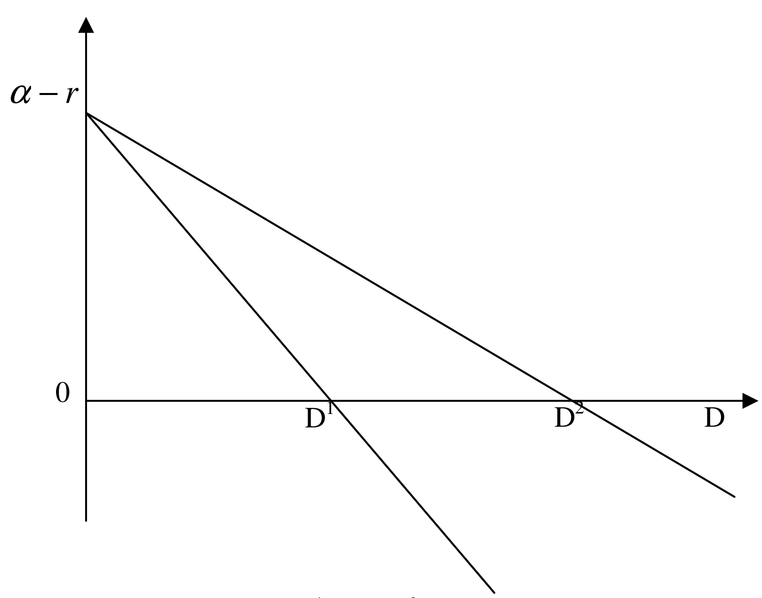
By the previous remarks, except in the borderline case in which the expression in equation (8) equals zero, the economy will settle down to either a low-growth equilibrium (LGE), where $z = 0$, or a high growth equilibrium (HGE), where the growth rate $z = \bar{z}$. From equation (8) it follows that economy settle down to HGE if

$$D < \frac{\alpha - r}{r - \bar{z}} \equiv D^2 \qquad (9)$$

while the condition for LGE is:

$$D > \frac{\alpha - r}{r} \equiv D^1 \ . \qquad (10)$$

These conditions can be depicted in the following figure



In this picture, area between D^1 and D^2 can be characterized as indeterminacy area as economy can settle down either to high growth or to low growth. So the economy definitely will exhibit high growth if initial debt, D, is lower than D^1 and it will exhibit low growth if initial debt is higher than D^2. This can be explained with simple intuition: the higher the initial debt, the higher will be associated tax burden for servicing the debt; so that incremental growth added by debt usage will decrease until debt exhibits negative impact on growth. Furthermore, recalling the solvency condition in equation (7), growth reduces tax rate necessary for servicing the debt, while low economy growth will increase rate of tax burden, which in turn will induce low rate of return on capital accumulation, thus giving rise to low growth. This reverse causality (from growth to tax burden) lies in the heart of the indeterminacy result.

Going further, from the above figure we can see that a small reduction (increase) in initial debt can cause a sizable effect on growth. Suppose that the economy exhibits initial debt that is just more than D^2 (just less than D^1), then slight debt reduction (slight debt increase) will place the economy in the indeterminacy region where high (low) growth is possible, but it is not necessary to occur.

It is possible to show that the GHE is Pareto superior to the LGE. Using equations

(7) and (5) we get:

$$V = \frac{\alpha - z}{r - z} - D \qquad (11)^*$$

Now we can argue that if GHE exists for some positive initial debt then $\boldsymbol{\alpha > r}$ must hold (it is obviously seen from equation (9)). This condition in turn implies that rise in z raises wealth, V. This means that in LGE, where $\mathbf{z = 0}$ wealth, V, is lesser than in HGE, where $z = \bar{z}$.

To show an influence of international interest rates on economy possibility to grow with some rate let express the region boarder in terms of the initial debt GDP ratio.

Hence $\delta^1 = \frac{D^i}{\alpha}$, (12)*

where i = 1, 2 (according to the debt critical values).

So by equations (9), (10) and (12) we have the following expressions:

$$\delta^1 = \frac{1}{r} - \frac{1}{\alpha} \quad (13)^*$$

and

$$\delta^2 = \frac{1}{r-z} - \frac{r}{(r-z)\alpha} \quad (14)$$

From these expressions we can see that a permanent fall in international interest rate increases the size of the region where only HGE exists, and increases the lower bound on the debt/GDP ratio above which only the LGE exists. Thus, a permanent drop in the international interest rate makes high growth more likely. In turn, the indeterminacy region ($\delta^1 < \delta < \delta^2$) shifts to the right.

Chapter 4

EMPIRICAL ANALYSIS

4.1. The Econometric Model

In order to investigate the impact of external debt on growth, as the starting point, it will be used the econometric model that was represented in the Pattillo et al. (2002) paper. In order to find out the level of external debt at which the marginal impact of debt on growth becomes negative it is necessary to employ a quadratic of the following form:

$$\mathbf{Y}_{it} = \alpha_{it} + \beta \mathbf{X}_{it} + \gamma_* \mathbf{D}_{it} + \delta_* \mathbf{D}_{it}^2 + \varepsilon_{it} \qquad \textbf{(1)}$$

where $\mathbf{X}_{it}$ is the set of control variables **D** represents the debt to GDP indicator. So, in order to find out whether the hypothesis of non-linear effect of debt on growth is confirmed the regression of quadratic specification will be run first and then we will see whether the coefficients on linear and quadratic terms are significantly deferent from zero. If the coefficients are significantly deferent from zero we can find out the peak of the quadratic function that identifies the level of debt at which the marginal impact of debt on growth becomes negative. This peak can be identified as the level of debt to GDP ration where growth is maximized. This can be found by solving simple maximisation problem.

Running ahead, we would like to note that our specification involves the logarithmic form of Debt indicator, so we consider it when we solve the maximization problem:

$$\frac{\partial Y_{it}}{\partial D_{it}} = \frac{\gamma}{D_{it}} + \frac{2\delta * \ln(D_{it})}{D_{it}} = 0 \qquad \textbf{(2)}$$

where $\ln(D_{it})$ is the logarithm of D_{it}.

Then expressing Debt indicator we will get the optimum level:

$$D_{it} = \exp(-\frac{\gamma}{2\delta}) \qquad \textbf{(3)}$$

Taking the second derivative and comparing it to zero we check whether it is either maximum or minimum:

$$\frac{\partial^2 Y_{it}}{\partial D^2{}_{it}} = -\frac{2\delta - \gamma}{D^2{}_{it}} - \frac{2\delta * \ln(D_{it})}{D^2{}_{it}} \qquad \textbf{(4)}$$

In order to find out the average level of debt to GDP ration at which further increase in debt to GDP ratio influence negatively further growth we employ the following specification with quintile:

$$\mathbf{Y}_{it} = \alpha_{it} + \beta\mathbf{X}_{it} + \gamma_{1*}\mathbf{d}_1 + \gamma_{2*}\mathbf{d}_2 + \gamma_{3*}\mathbf{d}_3 + \gamma_{4*}\mathbf{d}_4 + \varepsilon_{it} \qquad \textbf{(5)}$$

Where $\mathbf{X}_{it}$ is the set of variables specified above, $\mathbf{d}_1$, $\mathbf{d}_2$, $\mathbf{d}_3$, $\mathbf{d}_4$ are dummies representing inclusion in the first to the fourth quintile of debt (where the quintiles are constructed separately for each debt indicator debt to GDP after ranking all debt observations).

4.2. Econometric Methodology

In our study, we use a panel data technique as this allows us to exploit simultaneously ross-sectional and time-series properties of our data.

In this study, we make use of different estimation techniques (fixed and random effect as well as pooled OLS) and apply different tests toward the discrimination between those estimation techniques.

As Pattillo et al (2002) pointed out the model with specified variables can exhibit the endogeneity problems. Most likely, this problem can arise from the endogeneity between growth and debt indicator as the main direction of this influence is not clearly defined. There are two directions of this influence, which could take place: from one point of view root, cause can arise from preferences of creditors, which can give their loans to those countries, which exhibit slow growth (causality from debt to growth). However, from the other point of view the same creditors may have preferences to give credits to those countries, which show improving in the growth rates (causality from growth to debt). In addition, another variable such as investment rate can be endogenous to the growth rate of country. If the debt and the investment rate exhibit endogeneity problem, this in turn will cause conventional OLS estimation to generate biased and inconsistent estimates. In order to manage with this problem we will proceed with instrumental variable estimation technique. This can be done by instrumenting endogenous variables with appropriate instruments, i.e. finding such instruments that would significantly correlate with other endogenous variables but do not correlate with error terms from the main equation. On the first step, we should find the set of instruments for our hypothetical instrumented variable and test their contemporaneous significance using conventional F-test. On the second step, we test the overidentified restrictions, i.e. whether instrumented variables do not correlate with error terms from the main equation (from the second step of Two

Stage Least Squares). On the third and last step, we test the null hypothesis of endogeneity of the variables under consideration as well as the consistency of simple OLS estimates.

In our specification, we do not suffer from those problems from which suffered specification of Pattillo et al (2002) as we do not make use of dynamic panel data estimation technique. Here we deviate from the specification developed by Pattillo et al in that they included log of income per capita lagged one time period. Our specification does not follow their one as they used the average of all the variables for three years and consequently considered income per capita lagged one time period as initial income per capita on the beginning of each of the subsample, i.e. every three years. As we cannot afford to divide our sample in some subsamples because of the quite short time period we took real GDP per capita in the 1989 year as initial GDP per capita.

4.4. Variable Consideration

The panel data model has *real per capita growth* as the dependent variable, and on the right hand side includes Debt over GDP, Debt over GDP squared, the investment rate, initial real GDP per capita, initial secondary school enrolment rate (all in logs), inflation rate, broad money over GDP, the population growth rate, De Melo index, government consumption and fiscal balance to control for differences in total factor productivity. Next we explain our motivation to include this set of variables into our analysis.

Growth rate of population. This variable is taken to into account in order to be in line with neoclassical growth models. This variable has a negative effect on the steady-state level of output per effective worker.

Investment rate is considered to reflect positive impact of physical capital on growth.

Fiscal balance like inflation is considered as major indicator of the total macroeconomic situation in the country.

Inflation rate is called for to proxy macroeconomic stability which was quite important factor in the transition economies as stabilization of inflation is considered as one of the key factors which contributes to growth.

Broad money to GDP. This variable measures financing deepening as well as can be good proxy for development of the financial system. In order to get rid of the possible endogeneity of this variable we lagged it one period.

Size of the government. In the growth literature, this variable is highlighted as quite important variable in determining economic growth. This variable is thought of as a policy variable. Empirical investigations of the effect of government size on economic growth are quite disputable, for example, Sala-i-Martin (1992) found that this variable negatively affected growth in its growth regression. At the same time Chadha and Coricelli (1997) emphasized the importance of this variable in their theoretical model of transition as government should support efficient restructuring of economy (consequently and economic growth). Going further, it is worth to mention that Sala-i-Martin showed in his model of endogenous growth that government expenditures can take inverted u-shaped form of effect on growth. As a proxy to this variable, we take the share of government consumption over GDP.

Those variables, considered above, are very standard for the growth regressions in the empirical literature, especially in the studies concerning developing and developed economies. Actually, they are traditionally used as control variables when other factors are of research interest (foreign direct investments, religion etc.).

In order to take into account different specific for situation which were in the transition countries we would like to add some other variables which were found significant in the explaining the growth in these countries.

Initial real GDP per capita. According to Coricelli et al (2002), this variable is included in order to capture differences in the initial conditions of transition economies at the beginning of their transition.

Initial secondary school enrollment ratio is called for to measure initial human capital endowment variable in the transition economy and its function is very similar to the Initial real GDP per capita variable.

De Melo Index. In order to capture policy environment in the context of macroeconomic development of countries under consideration we constructed index according to technique developed by De Melo (1996). This index is supposed to capture overall environment development as it consists of five other indexes, such as price liberalisation, foreign exchange and trade liberalisation, small-scale privatisation, large-scale privatisation, banking sector reform developed by World Bank. These separate indexes measure different processes inherent to transition economies. This fact makes index developed by De Melo in some sense universal to measure environment development. The description of the construction of this index is represented later.

Table1. **Expected signs of the variables**

Independent variable	Quadratic specification
Initial GDP per capita	Negative
De Melo index	Positive
Secondary school enrolment rate	Positive
Investment rate	Positive
Population growth rate	Negative
Broad Money	Positive
Inflation rate	Negative
Size of the government	**?**
Fiscal balance	Positive

Initial GDP per capita is expected to have a negative coefficient, which is in line with economic theory, e.g. this supposes that the more income we had initially the less is the growth in the future. The coefficient on population growth is also expected to be negative, in the same time the coefficients on investment and schooling rates are predicted to be positive as they reflect accumulation of physical and human capital respectively. De Melo index is also expected to have positive sign, as it reflects movement of the same direction both in the trade and in countries' productivity. As this index is composite one it should reflect overall movements in the internal and external price liberalization as well as reforms in the banking system which in turn should be beneficial to the country trade and other activities. Therefore, the trade should give a rise to growth through transfers of knowledge and efficiency gains.

4.4. Data Description

All data, which were employed in the analysis, were taken from the World Bank Development Group databases (World Development Indicators CD-ROM) and from European Bank for Reconstruction and Development Transition Report 2002. As we employed our investigation in the context of panel data, it was important to use the same source for all needed data as this technique demands data to be poolable. (For example, all the data should be measured using the same technique). We use the unbalanced panel, which consists of 21 cross sections and from 5 to 7 time periods. In this sample were included the following transitional countries (post soviet countries): Albania, Azerbaijan, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Slovenia and the Ukraine. Each of these countries was estimated within the period of **1993-1999**.

In our specifications, we employed a composite index of policy environment, which was constructed according to methodology developed by De Melo (1996). This index consists of five other indexes (price liberalisation (PL), foreign exchange and trade liberalisation (FE), small-scale privatisation (SS), large-scale privatisation (LS), banking sector reform (BS)) developed by World Bank in order to mirror different processes which take place in transition economies. De Melo index was calculated according to the following formula:

Demelo[17] = PL*0.3 +FE*0.3 + (SS + LS + BS)*0.4

[17] The correspondence between EBRD Indexes and De Melo's composite parts of his index is presented in the Table 17 (Appendix U) in the appendix.

The summary statistics on the main variables are presented in the appendix (Table 2).

As a first step in exploring the relationship between growth and debt, we would like to pay more attention to the summary statistics of our main variable – external debt. All the data on external debt has been taken from World Development Indicators CD-ROM. In our study, following the usual measure of external debt, we use external debt as a share of GDP. According to the data we used in our study, the average official external debt in transition countries is slightly more than 35 % of GDP, which is quite high value. In Ukraine this indicator exceeded this average value and amounted to 36,5 % of GDP in the 1999 year. (Appendix B, Figure 2)

Figures 2 and 3 (Appendix B) plot the progress of the average debt indicator over time. The average values of external debt were computed for all countries. As figures show Debt to GDP ratio have been continuously increasing over specified period (For example in the Ukrainian case), without any significant decline in its growth rate.

As it was stated above, the following data are used in the regressions: growth real GDP per capita as the dependent variable, initial GDP per capita, the investment rate, the secondary school enrolment rate, inflation, the population growth rate, openness index (as instrument), debt to GDP, government consumption, fiscal balance (central government), De Melo index, Broad money over GDP. GDP and openness indexes were taken from World Development Indicators (2001) CD, and some observations (only two) were taken from database of IMF. Data on initial GDP per capita and the secondary school enrolment rate were taken from Coricelli et al (2002).

Chapter 5

MODEL ESTIMATION

As it was mentioned above, we proceeded with estimation of the growth equation with both OLS and panel data technique. At the very beginning we performing F- test for common intercept in our pooled OLS estimation and it rejects the hypothesis of the common intercept in the favour of panel data model, i.e. pooled least squares is not the efficient estimator. It can be seen from the Table 3 (Appendix H) that performing the Breusch and Pagan Lagrangian multiplier test for random effect we got very small p-value. This value is almost twice as a large as 95% critical value for chi-squared with one degree of freedom, which in turn points out that we can reject the null hypothesis of zero variance of the individual effects disturbance term. Therefore, the results of the test are to reject the null hypothesis in favor of the random effect model. We estimated both random and fixed effects model and proceed further with tests in order to discriminate between them by means of Hausman test. Chi-square statistics for Hausman test pointed out in favour of alternative hypothesis that random effect is not consistent and efficient estimator, so we keep in line with fixed effect model as it is more appropriate model to employ in our case (Table4, AppendixI).

Going further, we should recall that we suspected our specification to suffer from endogeneity problem. So in order to manage with the problem we run Generalized Two Stage Least Square, further as G2SLS, and Fixed-effects IV (instrumental variable) regression Table 7 (Appendix K). Using these regressions we instrumented investment rate and Debt over GDP indicator with broad money lagged one period, log of investment rate lagged one period, inflation rate lagged one period, Debt over GDP indicator lagged one period as well as with all other explanatory variable as instruments. As we used G2SLS and Fixed-effect IV techniques, we should make sure that those instruments are valid and perform further tests on this issue. On the first stage, we found instruments, which explain variation of such variables as investment rate and Debt over GDP indicator, by means of conventional F-test on join significance of our instruments taking into account R-squared of those regressions (Appendix J). As potentially there are more instruments than suspected on endogeneity variables we perform overidentified restriction test to be sure that our instruments are valid ones[18]. The test pointed out that we cannot reject our null hypothesis of orthogonality between contemporaneous errors and our instruments at the p-value of 0.51. So, in order to test further our main hypothesis of endogeneity, on this step we proceed with Wu-Hausman test to check whether our variables are subject to endogeneity problem. Running the mentioned test we found out that p-value is high enough (0.58) to favour null hypothesis pointing out that even though Fixed-effects IV model is consistent the simple fixed effect model is consistent and efficient, so we proceed further with simple fixed effect model.

Beside those techniques, we used Generalised Least Squared time-series cross-sectional regression in order to make use of controlling for heteroscedasticity in our model. This heteroscedasticity is inherent as it stems from the group-wise clustering of the data; consequently, heteroscedasticity becomes to be characterized as group-wise heteroscedasticity. The results from this equation are presented in the Table 4 (Appendix I).

[18] On the second stage we checked the orthogonality conditions between instrumented variables and residuals from the Fixed-effects IV as more appropriate model to employ in our case.

Table 4: Growth regressions with quadratic specification (Panel)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)	Panel Regression (FGLS)
1	2	3	4
Debt over GDP (log)	**-0.371(0.0074)**	**-0.258(0.0174)**	**-0.13(0.045)**
Debt over GDP (log) squared	**-0.101(0.0094)**	**-0.069(0.0284)**	**-0.028(0.122)**
Inflation (log(1+ growth rate))	-0.849(0.0498)	-0.686(0.0606)	-0.566(0.004)
Investment rate (log)	**0.220(0.0743)**	**0.201(0.0352)**	**0.137(0.039)**
Government consumption	0.022(0.0047)	0.010(0.0446)	0.006(0.030)
Fiscal balance	0.016(0.0648)	0.021(0.0081)	0.019(0.000)
Population growth rate	-2.238(0.1497)	-1.347(0.6354)	-1.311(0.541)
De Melo index	0.246(0.0006)	0.300(0.0000)	0.316(0.000)
Broad money over GDP	-0.008(0.0116)	-0.002(0.1320)	-0.00065(0.470)
Initial GDP per capita (log)	-	-0.175(0.0088)	-0.182(0.000)
Secondary school enrolment (initial)	-	-0.339(0.2769)	-0.158(0.248)
Number of observations	107	102	102
R-squared/ Log likelihood	0.786	0.713	64.11483
F'/Wald-statistics"	35.392'(0.0000)	134.78" (0.0000)	174.62" (0.0000)
Hausman test	-	$\chi^2(9)= 24.24$ (0.0039)	-

Note p-value in parentheses. All regressions are run with constant. *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. For FGLS Log likelihood is reported

We shall now discuss the results of our estimation. The main results of our work are tabulated in Table 18 (Appendix V). It can be seen in general almost all models perform quite well as they managed to explain not less than 70% of the variation in countries' growth rates. As it can be readily seen from the Table 4 (Appendix I) that linear debt indicator and its quadratic term are highly significant in the fixed effect model even at 1% of significance level, but in the FGLS regression its significance was pressed down up to 5% significance level. Even though we get negative coefficients both on linear and quadratic terms, from the visualized relationship between growth and external debt (Appendix C) we can see that real relationship between them is inverted U-shaped one.

In order to estimate the average level of Debt to GDP at which, ceteris paribus, its marginal and average impact on economic growth becomes negative we employed quadratic and quintile regressions correspondingly. Having estimation results from quadratic specification, we took first derivatives (second derivatives are all negatively signed) on all our specifications and rearranged those equations in order to express the optimal level of the debt to GDP ratio at which growth is supposed to be maximized. The values were found to vary in the rage from approximately 11% of external debt of GDP to 18% of external debt of GDP.[19] In addition to that range we calculated its confidence interval, where it was specified as interval between minimum value of confidence interval for lower optimum point and maximum value of confidence interval for upper optimum point (see Appendix D)[20]. From our quadratic specification we calculated the range for the effect of doubling the external debt to GDP indicator (where initial points for doubling were chosen according to the optimal points found from estimation results). Doubling debt indicator decreases growth in real GDP per capita from 0.11% to 0.13% per annum and this estimated impact lies in the range from 0.105 to 0.135% of decrease in real GDP per capita growth, which corresponds to 95% confidence interval (see Appendix E)[21]. Analyzing our quintile specifications (Tables 12, 13) it can be seen that we cannot to make any inference as all of the dummies are insignificantly different from zero in all fixed effects models. But if we consider random effects models, which take into account time invariant differences (For example, such as initial real GDP per capita, initial secondary school enrolment rate), we shall see that first two quintiles

[19] The magnitude of influence of debt on growth is derived in the appendix. Growth maximizing points were chosen as initial ones.

[20] Methodology for calculation of confidence interval for point estimation is presented in the appendix.

[21] The methodology for calculation of confidence interval for point estimation is the same to the previous case.

are significantly different from zero. This, in turn, can point out on the fact that at least in the range from 0 to 35% of external debt of GDP external debt does not influence negatively economic growth. It may be suggested that growth-maximizing point may be located somewhere between 0 and 35% of external debt of GDP, which is in line with our previous findings from quadratic specifications. Nevertheless, inference, which we made from quintile regressions, should be considered only as tentative one as all dummies are highly insignificant in all fixed effects models (which were chosen according to conventional test procedure)[22].

For now, according to our findings, it may be stated that almost all transition countries are overindebted in the sense that they do not maximize their growth rates, which can be seen from comparing figures 5 and 6 (Appendix D).

For example, according to the Table 4 the magnitude of (negative) influence of the doubling the Ukrainian debt on economic growth will be approximately equal to 0.169%[23].

Another thing which is seemed to be good is that almost all models show consistency with one another, i.e. in all models (except for Fixed-effect IV, Appendix K) all variables preserve their signs and their coefficients are quite comparable across them, which in turn give hope of the right specification.

It is interesting to note that almost all variables have expected signs, the only exception is "Broad money over GDP" variable which appeared to have negative sign. But according to Coricelli et al (2002):

"One possible interpretation for such effect could be that because of the phenomenon of monetary overhang in many centrally planned economies, this indicator in fact can measure a distortion rather than true financial deepening." Another reason, which Coricelli et al pointed out, is that *"… negative sign on broad money over GDP in the regression … signals the presence of a credit crunch in the whole sample of countries examined."*

[22] Quintile ranges are represented in the appendix.

One interesting fact is that investment rates are significant in all of the models, specified for the whole sample of countries, and quite high in magnitude, varying from 0.14 up to 0.22. Therefore, we could conclude that our results mostly in line with those which were found before by other researchers, e.g. Coricelli et al (2002). The coefficient on the initial real GDP per capita has quite high magnitude, but it still does not deviate greatly from one found by Coricelli et al (2002). They found that in their regression this coefficient took the value equal to -0.12 while in our specification it takes value from -0.175 up to -0.182 which of cause cannot be viewed as huge deviation.

The variables Government consumption, Fiscal balance, De Melo index are highly significant and have positive signs under all specifications As it was expected according to the theory Fiscal balance and De Melo index have predicted signs, while the theory is not so confident about direction of influence of government consumption. Therefore, as we stated before, the positive sign on the government consumption as well as its high significance may confirm statement of Chadha and Coricelli (1997) who emphasized that government should support efficient restructuring of economy.

In general, our findings agree with those of Coricelli: the lower the rate of inflation and the higher the budget surplus the higher the economic growth will be.

Analyzing the initial human capital conditions of transition economies, we can see that in either model it is highly insignificant which in line with findings of Fischer and Sahay (2000). Even though this variable, according to the existing theory, is expected to be positively signed, Fabrizio Coricelli (2002) rationalized its possible insignificance:

”… *the interpretation of human capital variables could be misleading for transition economies. High levels of education do not necessary reflect a high level of human capital usable in a market economy. The characteristic of the education system and especially the reliance on*

---

[23] The level of 1999's year indebtness was chosen as initial point.

vocational schools may have produced a bias towards skills not easily adaptable to the new environment."

As it was emphasized former USSR republics began their transition from the zero debt option and in order both to see whether they have significant difference in the growth determinants, from the whole sample, and to perform some stability tests on the robustness of our model we employ restricted sample and run separate regression only on the set of former USSR republics.

Estimation results employing restricted sample are presented in the Tables 9-12 (Appendices O - R). As it can be seen, almost all variables preserve their initial signs and do not deviate greatly from the above-mentioned results, which in turn emphasize on the quite good stability of the model. There are some exceptions, which can be seen from regressions on the restricted sample. The first is that random effect model was chosen for estimation of the restricted sample. The second difference, which is worth to note, is that in the model for the former USSR republics investments appear to be quite insignificant under all specifications. P-values for rate of investments variable vary from 0.390 to 0.769.As it can be seen all variables preserve their initial signs and do not deviate greatly from the mentioned results. One thing which should be noted is that debt indicator is still slightly higher than in the specification with investment rate.

Going further, we run regressions with time dummy in order to test on robustness of our initial specifications by adding time dummy for period from 1994-1999 and to capture influence of the time -varying variables which were not explicitly specified in the models (dummy on 1994 should be dropped in order to get rid of multicollinearity). As it can be seen from the Tables 8,10,12,14 (in the Appendices L, N, P, R) all variables preserve their initial signs and do not deviate from the mentioned results (without time dummy). This fact, in turn, can emphasize on the quite good stability of the model. The only important exception, which can be emphasized is that coefficients on the debt indicator became much bigger in magnitude, i.e. they vary from-0.47 to -0.55 for linear term and from -0.109 to -0.161 for quadratic term and more significant than they were before. It is worth to note that our choice between fixed and random model, in this case, is consistent with our previous choices, i.e. fixed effects model for the whole sample and random effects model for the restricted sample.

So far we were concerned with the influence of debt on economic growth and did not pay any attention to another hypothesis we wanted to test: channel through which debt may influence the growth rate. Theoretical literature pointed out that the most likely this channel could occur through the investment channel. In order to test this hypothesis we run our initial model with the same specification but excluding investment rate, which is quite standard procedure. The same procedure was made by Pattillo et al (2002) and they found that when they "***exclude the investments from regression the results are similar, although in some cases the debt coefficient becomes larger***".

Testing this hypothesis we found out almost the same story in the case of transition countries. In the Tables 9,10,13,14 (Appendices M, N, Q, R) we reported our experiment with our model, excluding investments rate from our specification. From those tables it can be seen that results are mostly the same to those we found before when we compared results from regressions with and without time dummies: debt indicator is highly significant under this specification and has the negative sign. Other variables behave in the exactly the same way as in the specifications we considered before, preserving their significance and signs. *Therefore, we may conclude that investments are not the main channel through which debt influences growth rates in transition countries* and we can make the same conclusions as Pattillo et al made: it is small part of the impact of external debt on growth owing to lower investment rate. Those results suggest that it is very likely that the influence occurs through the quality rather than through volume of investments.

As it was highlighted in the literature review there exist some possible explanations to the found inverted U-shaped relation between external debt and growth. The very first is that when capital is scarce in the country borrowing is conductive to the growth as its marginal productivity in that country is quite high to repay the debt from the earnings. However, when country reached high enough level of indebtness the productivity of its capital is not able to produce enough to repay debt without reducing rates of further growth. Another explanation is quite intuitive and comes from debt overhang theory: the first stages of borrowings and repaying are the same but the further borrowing lead to negative expectations of current and potential investors concerning further taxation policy of government. Those negative expectations force investors either to forbear from further investment or to invest only in short term projects, which in turn can be quite unfavorable for long run equilibrium growth.

One thing, which deviates from previous empirical finding, is that we found the growth-maximizing range which is narrower and is closer to the origin. These two findings can be rationalized as well. The more narrow range for growth-maximizing levels of debt to GDP ratio and closer to the origin location can be explained by the fact that our sample consists of quite homogeneous countries which in the recent past 15 out of 27 constituted the same country while the rest of those countries were closely (economically, politically and mentally) related to the former USSR. That similarity can be the main factor which contributes to our finding of quite narrow and close to the origin range of growth maximizing debt to GDP ratio.

Chapter 6

CONCLUSION AND POLICY IMPLICATIONS

In earlier studies on the external debt in the developing countries a number of researchers found different directions of influences of debt on growth. However, few studies concentrated on non-linear effect of debt on growth in developing countries and none in transitional countries.

Our work attempts to find out the answer to the question about the relation between external debt and economic growth, which is quite important, particularly in the context of quick debt accumulation in transition countries.

We employed several econometric specifications such as specification with quadratic debt term in order to determine the range for debt to GDP ratio where economic growth can be maximized and with quintile specification - in order to determine the average level of debt to GDP ratio where further borrowing would be detrimental to growth. In addition to various specifications, we used different econometrics methodologies such as fixed effects, random effects and instrumental variable models and tried to identify the range for optimal level of debt to GDP ratio taking into account all the results from different models and specifications. Checking for robustness of our models, we estimate our regressions including and excluding time dummies as well as restricting our sample only to the former Soviet republics.

Before making any strong conclusions let us make some assumptions about our findings:

Let us assume that we used good underlying theory which shows the true relation between variables considered above, let us further assume that we specified right econometric model and the true relationships. Let us also assume that those relationships will hold in the nearest future, then if all of these assumptions hold simultaneously, we can make some certain conclusions for the sake of the future policy implications and economic development.

Based on our study we can state the following propositions:

- We found that the impact of external debt on economic growth in transition countries has inverted U-shaped pattern and it is presented in the stylized manner in Figure 4 (Appendix C). The optimal level of debt to GDP ratio at which economic growth can be maximized was found to belong to the range from 11% of debt of GDP to 18% of debt of GDP with 95% confidence interval in the range of 8.5% - 20.5% .
- The average effect of external debt to GDP ratio, estimated using quintile regression, at which further increase in debt to GDP indicator will be detrimental for further growth (point A in Figure 4) was not identified (from fixed effects model) from the model which was chosen according to conventional econometric tests. However, based on random effects model we suggested that negative average effect of debt on growth may correspond to the range from approximately 16% to 35% of debt of GDP.

Based on these results we can conclude that average country in our sample is overindebted in the sense that the growth is not maximized and its level of debt over GDP indicator reached marginal value at which further borrowing would be destructive for further economic growth.

In addition, we found that:

- Investments is an important ingredient of the economic growth in transition countries, while they were not found as a main channel through which debt affected economic growth.
- Government consumption as a proxy for its size appeared to influence economic growth positively.
- Macro-stabilization policy is also conductive for future growth.

In order to find some policy implications to our study we would suggest:

- Government should pay attention to such objectives as inflation, budget deficit and overall (external and internal) liberalization of prices.
- Government should pay more attention to debt management profile and particularly to its items of expenditure. It should try to direct it to productive use.

For further research we would suggest to consider investigation of impact of external debt on growth through its main determinants, such as public and private debt; in addition, we would suggest to investigate influence of external debt on growth through its different parts of expenditure, in particular expenditure on financial aid, investments in different economic sectors etc.

BIBLIOGRAPHY

1. Bauer, P. (1991), *The development frontier: essays in applied economic.* Hempstead: Harvester/Wheatsheaf.

2. Calvo, Guillermo A. (1998*)."Debt Growth and Economic Transformation: The Capital Flight Problem,"* New theories in growth and development, St.Martin's Press,

3. Claessens, *et al.* (1996), *"Analytical aspects of the debt problems of Heavily Indebted Poor Countries".* A paper presented to IMF/World Bank seminar in December

4. Cohen (1997),*"Growth and External Debt: A New Prospective on the African and Latin American Tragedies "* Center for Economic Policy Research Discussion Paper, No.1753

5. Cohen, D. (1995), *"How to cope with debt overhang: Cut flows rather than Stocks"* in Husain, Divan, and I, Eds. *Dealing with the Debt Crisis.* Washington, D.C: World Bank.

6. Cohen, Daniel and Jeffrey Sachs, (1986), *"Growth and External Debt under Risk of Debt Repudiation,"* European Economic Review, Vol.30.pp.529-550.

7. Coricelli F., Nauro F. Campos(2002).*" A Tail of two peripheries: an Empirical analysis of growth in transition economies"*IEA-Review Conference

8. De Melo Martha, Cevdet Denizer, Alan Gelb (1996)" *From plan to market: Patterns of transition*". Transition Economics Division Policy Research Department, World Bank.

9. Domar, Evsey D. (1946), *"Capital Expansion, Rate of Growth, and Employment",* Econometrics, 14 (April), 133-147.

10. Elbadawi, A. I., J. B. Ndulu., and N. Ndung'u (1997), *"Debt overhang and economic growth in Sub-Saharan Africa".* A paper presented to the

IMF/World Bank conference on External Financing for Low Income Countries in December

11. Griffin, K. (1970), *"Foreign capital, domestic savings and economic development,"* Bulletin of the Oxford University Institute of Economics and Statistics 32, 99-112.

12. Griffin, K. and J. Enos. (1970), *"Foreign assistance: Objectives and consequences," Economic Development and Cultural Change* 18, 313-27

13. Krugman,Paul,(1998),"Financing vs. Forgiving a Debt Overhang," Quarterly Journal of Economics, Vol.110,No.4,pp.1127-70

14. Lensink, R. and H, White. (1999). *"Is there an aid laffer curve?"* Credit research Paper No. 99/6. Nottingham: Centre for Research in Economic Development and International Trade, University of Nottingham.

15. Maureen Were(2001*) **"**Kenya Institute for Public Policy Research and Analysis" Wider Development Conference on Debt Relief,* Helsinki

16. Pattillo et al., (2002)*" External Debt and Growth",* IMF Working Paper.

17. Sachs,J. *," The Debt Overhang Of Developing Countries"* , in Ronald Findlay (Ed.), Debt , Stabilization and Development , Essay in Memory of Carlos F. Diaz-Alejandro (Oxford:Blackwell,1989).

18. Solow, Robert M. (1956), *"A Contribution to the Theory of Economic Growth"*, Quarterly Journal of Economics, 70, 1 (February), 65-94.

19. Swan, Trevor W. (1956), *"Economic Growth and Capital accumulation",* Economic Record, 32 (November), 334-361.

APPENDIX A

Mathematical Appendix

$Q = \alpha K \Rightarrow \dot{Q} = \alpha \dot{K} \Rightarrow$ Dividing the latter by the former $\Rightarrow \dot{Q}/Q = \dot{K}/K = z$

(5)* starting from equation (4) $V = \int_0^\infty [\alpha(1-\tau) - z_t] e^{-\int_0^t (r_s - z_s) ds} dt$

Let $Y = e^{-\int_0^t (r_s - z_s) ds} \Rightarrow$ differentiating we get the following expression $dY = -(r_s - z_s) e^{-\int_0^t (r_s - z_s) ds} dt \Rightarrow$ expressing dt and plugging in the (4)

We get $V = \int_1^0 [\alpha(1-\tau) - z] Y \frac{dY}{-(r-z)Y} =$

$$\int_0^1 [\alpha(1-\tau) - z] \frac{dY}{(r-z)} = \frac{\alpha(1-\tau) - z}{(r-z)} Y\Big|_0^1 = \frac{\alpha(1-\tau) - z}{(r-z)}$$

(6)* Differentiating equation (5) with respect to z

$\frac{\partial V}{\partial z} = \frac{-(r-z) - (\alpha(1-\tau) - z)) * (-1)}{(r-z)^2} = \frac{\alpha(1-\tau) - r}{(r-z)^2}$, further taking into account the assumption about the non-negative growth path of z and noticing that denominator is always is positive we get equation (6).

(7)* As the cash flow from taxation in every period is equal to $\tau Q = \alpha \tau K$ hence, to repay debt with all available future cash flows we get equation (7).

Going further and recalling the fact that $z \equiv \dot{K}/K$ we get $D = \alpha\tau \int_0^\infty e^{-\int_0^t (r-z) ds} dt$ then *let* $Y = e^{-\int_0^t (r-z) ds} \Rightarrow dY = -(r-z) e^{-\int_0^t (r-z) ds} dt$

Continuation of APPENDIX A

After expressing dt and plugging in the former formula we get

$$D = \alpha\tau\int_1^0 Y\frac{dY}{-(r-z)Y} = \alpha\tau\int_1^0 \frac{dY}{-(r-z)} = \alpha\tau\int_0^1 \frac{dY}{(r-z)} = \alpha\tau\frac{Y}{(r-z)}\bigg|_0^1 = \frac{\alpha\tau}{(r-z)}$$

(8)*Express the τ from equation (7) as $\tau = \dfrac{D(r-z)}{\alpha}$

And plug it into (6) we get the following expression

$$\operatorname{sgn}\frac{\partial V}{\partial z} = \operatorname{sgn}\left[\alpha\left(1-\frac{D(r-z)}{\alpha}\right)-r\right] = \operatorname{sgn}\left[\alpha - D(r-z) - r\right]$$

(11)*From equation (5) we can express τ in the following way $\tau = 1-\dfrac{V(r-z)+z}{\alpha}$.

Then plugging this expression in equation (7)

$$D = \frac{\alpha}{(r-z)}\left(1-\frac{V(r-z)+z}{\alpha}\right) =$$

$$= \frac{\alpha}{(r-z)} - V - \frac{z}{(r-z)} = \frac{\alpha - z}{(r-z)} - V \Rightarrow \quad V = \frac{\alpha - z}{r-z} - D$$

(12)*As GDP is equal to $Q_t = \alpha^* K_t$ and initially $K = 1 \Rightarrow$

This means that Q =α, which in turn implies $\delta = \dfrac{D^i}{\alpha}$

(13)*As at critical values (in the borderline case)

$$\operatorname{sgn}\frac{\partial V}{\partial z} = \operatorname{sgn}\left[\alpha - D(r-z) - r\right] = 0$$

we can express, taking into account that for LGE z = 0,

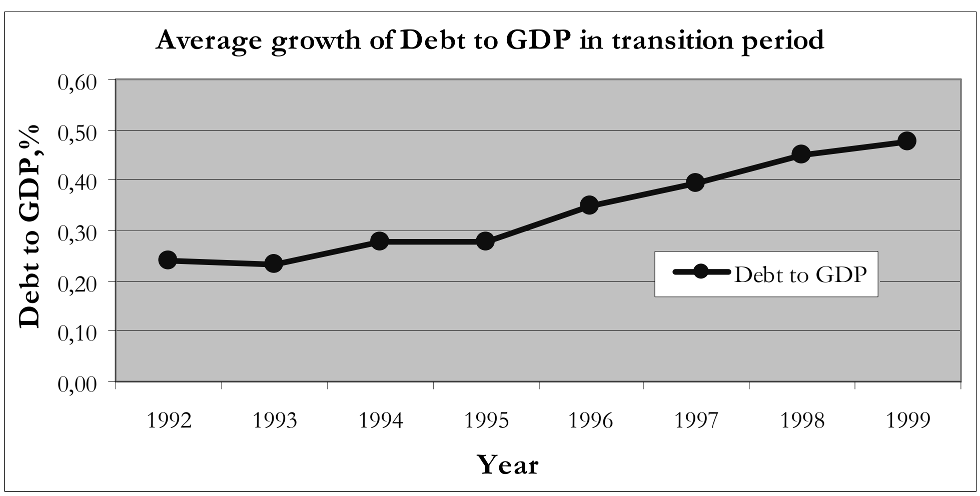
D as $D = \dfrac{\alpha - r}{r}$ and plug into the (12), so we get equation (13).

Equation (14), recalling that in this case $z \neq 0$, is derived in the same fashion.

APPENDIX B

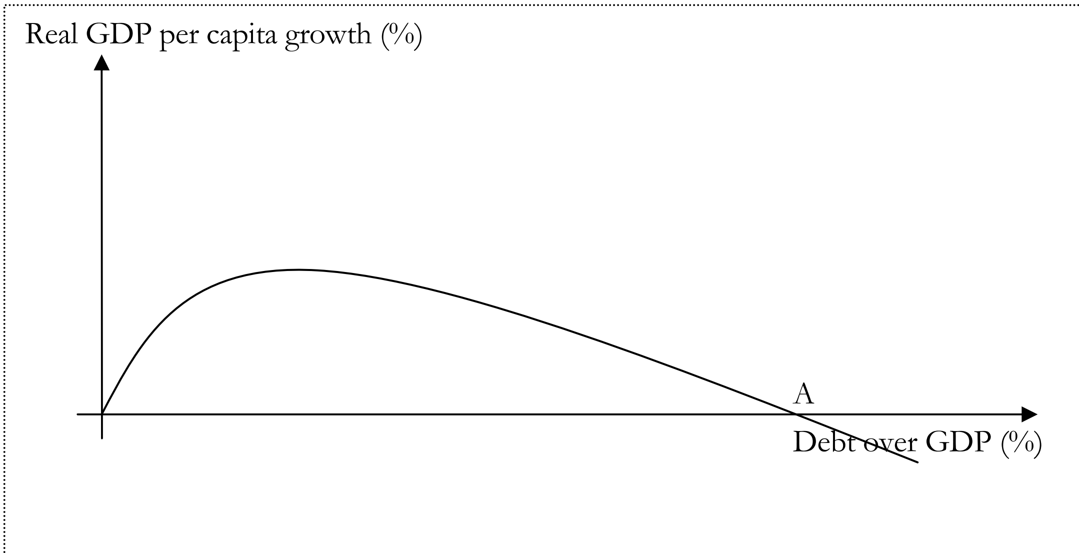
Figure 2. External Debt to GDP development in Ukraine during transition time

Figure 3: Progress of the average Debt to GDP Indicator in transition countries



APPENDIX C

Figure 4: Stylized shape of the non-linear relation between External Debt to GDP and growth



APPENDIX D

Figure 5. External Debt to GDP versus real GDP per capita growth in transition countries

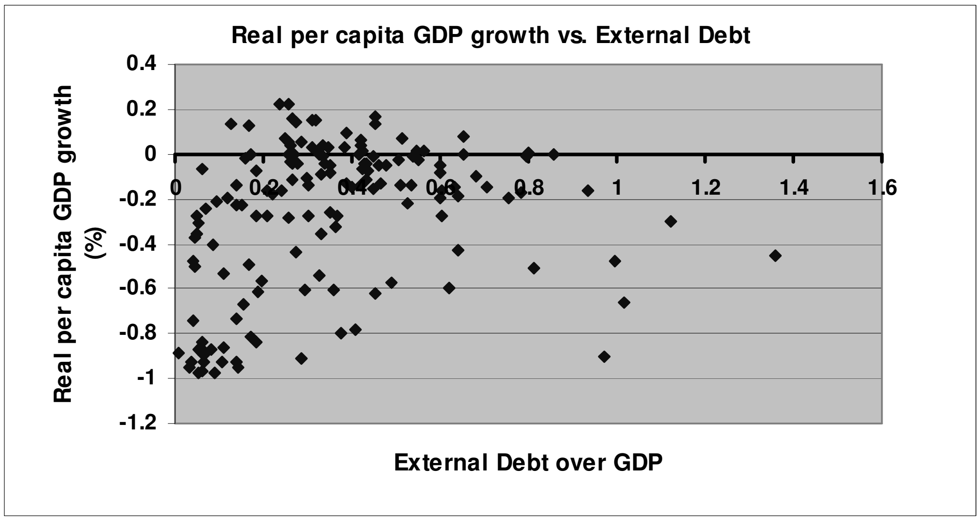
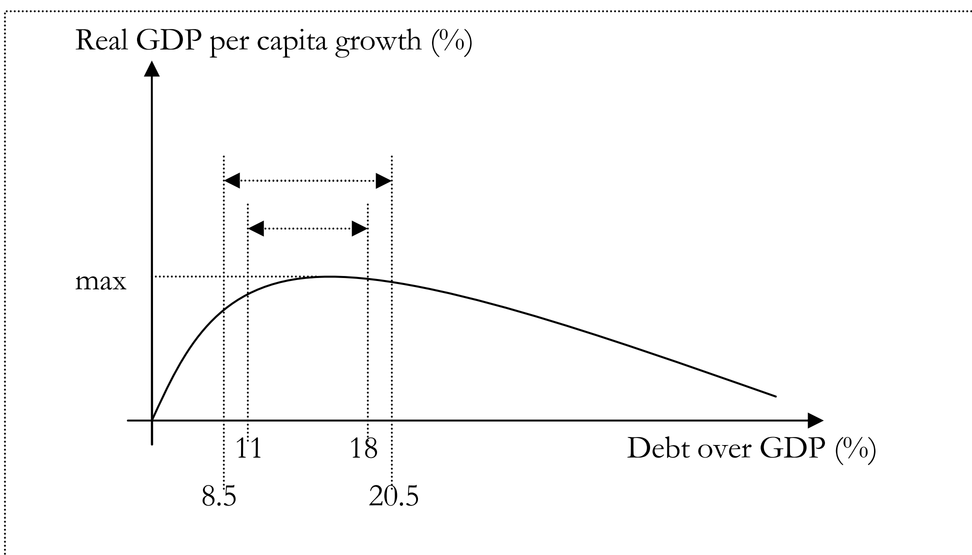
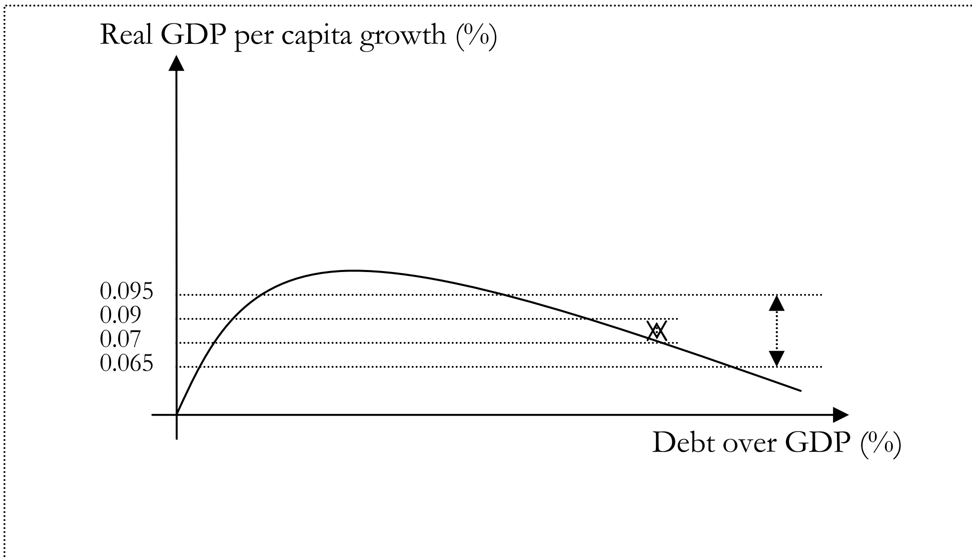


Figure 6.1: Stylized shape of the non-linear relation between External Debt to GDP and growth in transition countries



APPENDIX E

Figure 6.2: Stylized shape of the non-linear relation between External Debt to GDP and growth



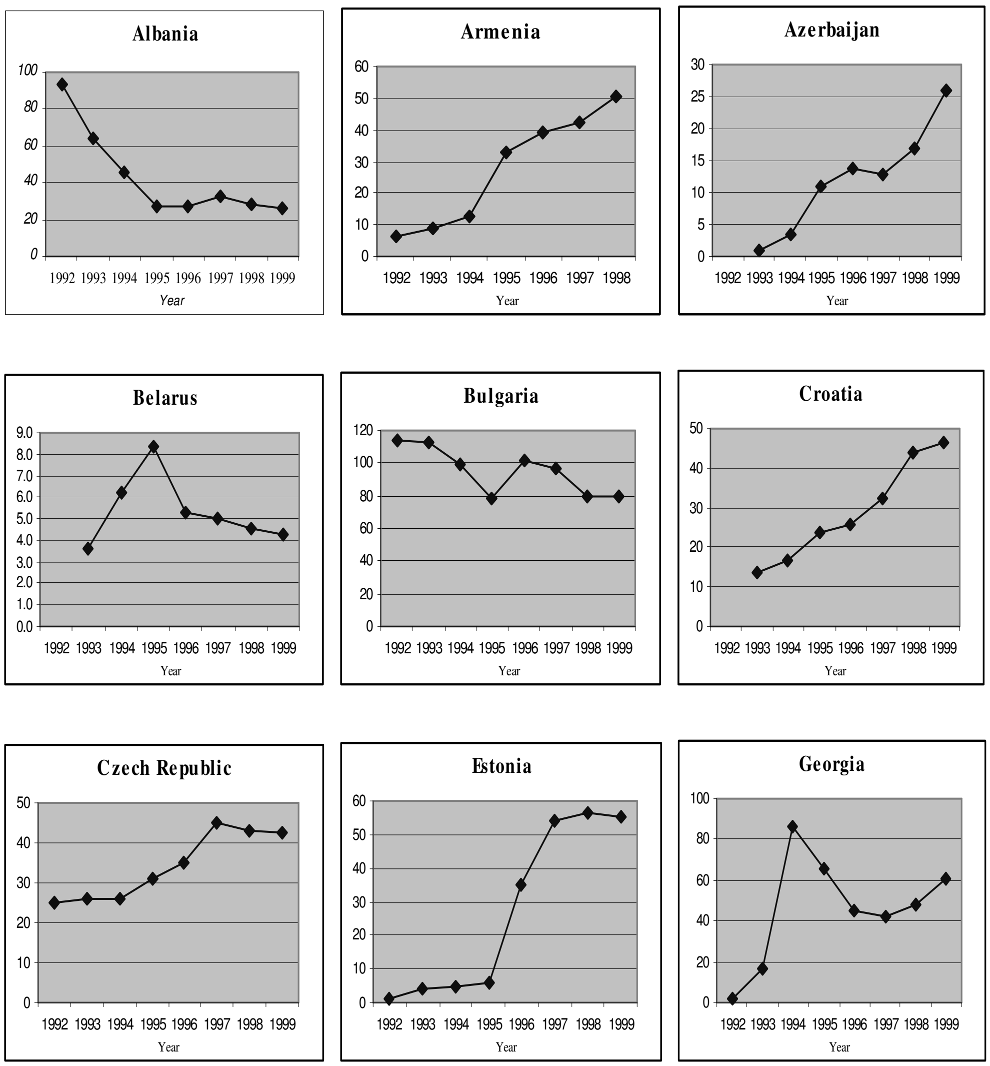
APPENDIX F

Table 2. Summary Statistic

	Obs.	Cross sections	Mean	Median	Maximum	Minimum	Std. Dev.
Debt to GDP	166	25	0.35383	0.32088	1.35838	0.008228	0.24690
Population growth,%	189	27	0.00107	-0.00046	0.06845	-0.06055	0.01398
Trade as a share of GDP,%	174	26	92.6931	91.22	172.9	37.33	30.0971
Secondary school enrollment in pre-transition year	161	23	0.87913	0.9	1.01	0.57	0.10022
M2 as a share of GDP,%	151	24	25.9026	20.761	71.273	4.832	16.7844
Growth of real GDP per capita	172	26	-0.27307	-0.16348	0.72001	-0.97733	0.35088
Government consumption as a share of GDP,%	168	25	17.2257	17.9908	29.8643	5.704835	5.17084
Budget balance as a share of GDP,%	184	27	-5.19130	-4.35	2.2	-54.7	5.60086
De Melo index	189	27	2.67984	2.87	3.92	1	0.79535
Log of initial GDP	175	25	8.30006	8.326759	9.35227	6.444131	0.59142
Log of (1+inflation growth rate)	144	22	0.51062	0.18424	3.92438	-3.87417	0.91372
Investment rate	167	25	0.21386	0.20387	0.46178	0.070003	0.06715

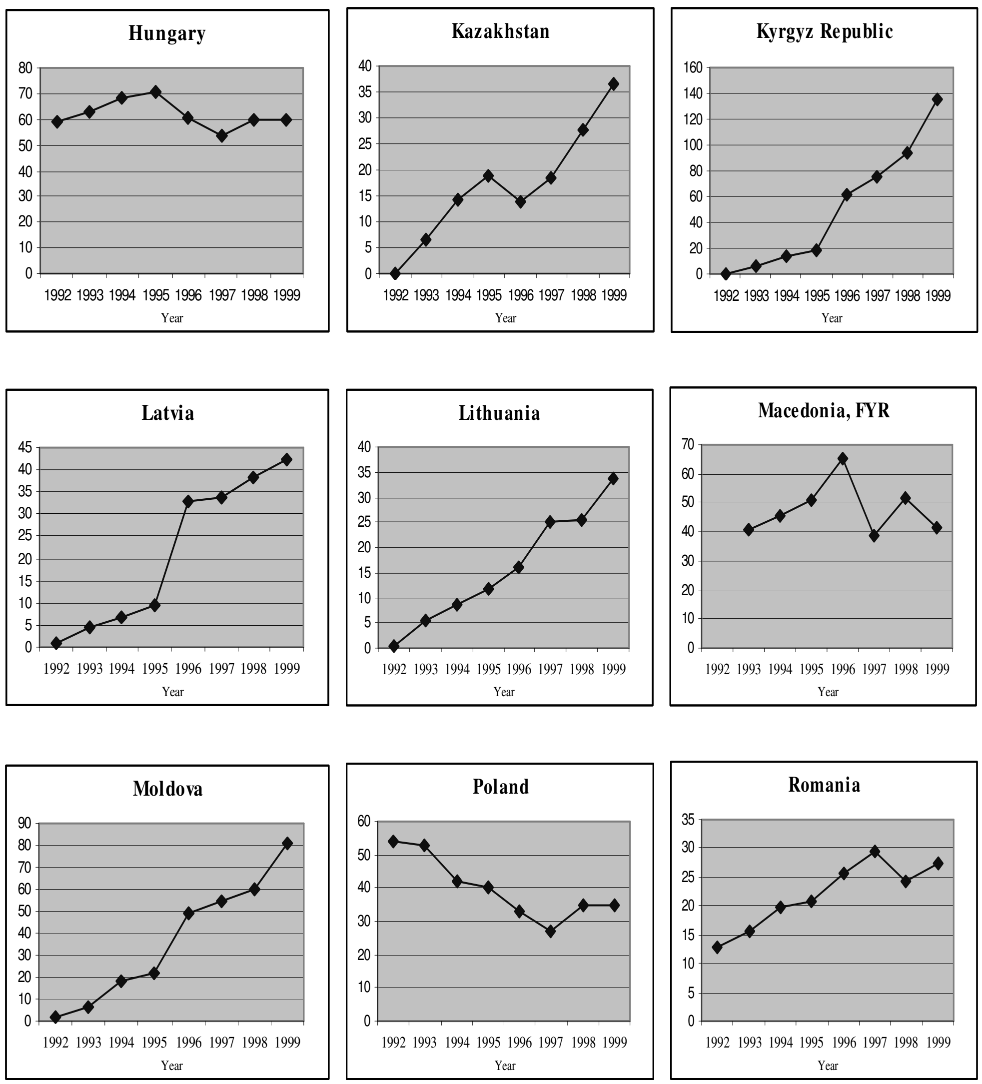
APPENDIX G

Figure 8. External Debt over GDP (%) in Transition countries during transition time



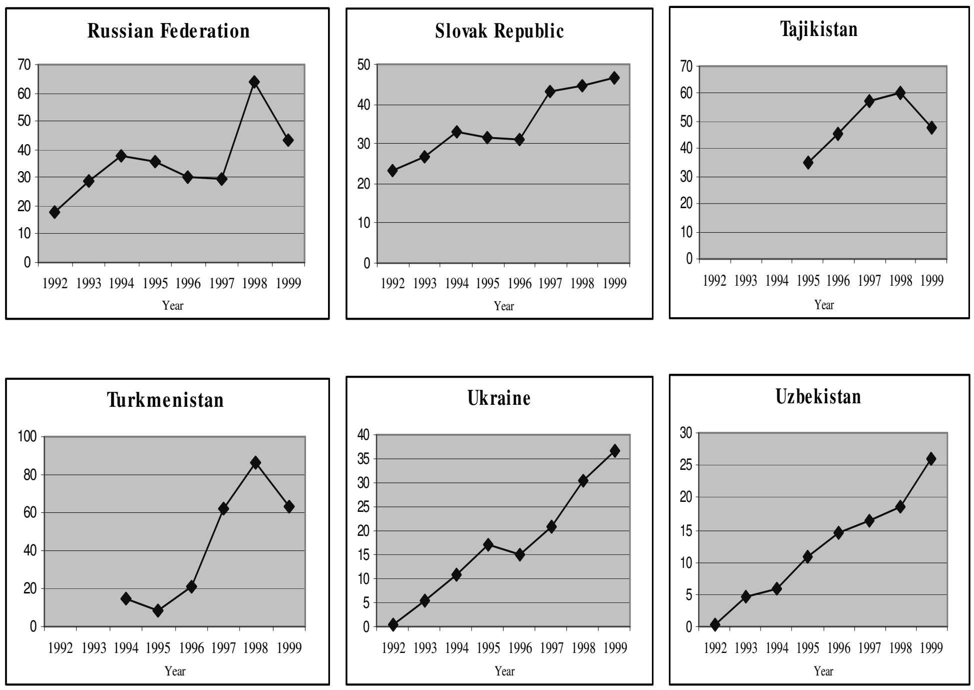
Continuation of APPENDIX G

Figure 9. External Debt over GDP (%) in Transition countries during transition time (continued)



Continuation of APPENDIX G

Figure 10. External Debt over GDP (%) in Transition countries during transition time (continued)



APPENDIX H

Table3. Pooled regression for quadratic specification

Dependent Variable: growth of real GDP per capita

Explanatory variable	Pooled OLS*
1	2
Debt over GDP (log)	**-0.169 (0.0629**)
Debt over GDP (log) squared	**-0.0401(0.1032)**
Initial GDP per capita (log)	-0.177 (0.0019)
Secondary school enrolment (initial)	-0.242(0.1915)
Inflation (log(1+ inflation rate))	-0.574(0.0350)
Investment rate (log)	**0.169(0.0942)**
Government consumption	0.0063(0.1477)
Fiscal balance	0.0218(0.0097)
Population growth rate	-0.791(0.7727)
De Melo index	0.31(0.0000)
Broad money over GDP	-0.00073(0.5277)
Number of observations	102
R-squared	0.631
F/Wald-statistics	F(9,77) = 15.70 (0.0000)
Breusch and Pagan Lagrangian multiplier test	$\chi^2(1)$=7.69 (0.0055)**

Note p-value in parentheses. All regressions are run with constant. * Heteroscedasticity was detected based on Breusch-Pagan test (at 5%level of significance), p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. ** this value almost twice as a large as 95% critical value for chi-squared with one degree of freedom. So, the results of the test are to reject the null hypothesis in favor of the random effect model.

APPENDIX I

Table 4. Growth regressions with quadratic specification with investment rate, without time dummy (Panel for the whole sample)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)	Panel Regression (FGLS)
1	2	3	4
Debt over GDP (log)	**-0.371(0.0074)**	**-0.258(0.0174)**	**-0.13(0.045)**
Debt over GDP (log) squared	**-0.101(0.0094)**	**-0.069(0.0284)**	**-0.028(0.122)**
Inflation (log(1+ inflation rate))	-0.849(0.0498)	-0.686(0.0606)	-0.566(0.004)
Investment rate (log)	**0.220(0.0743)**	**0.201(0.0352)**	**0.137(0.039)**
Government consumption	0.022(0.0047)	0.010(0.0446)	0.006(0.030)
Fiscal balance	0.016(0.0648)	0.021(0.0081)	0.019(0.000)
Population growth rate	-2.238(0.1497)	-1.347(0.6354)	-1.311(0.541)
De Melo index	0.246(0.0006)	0.300(0.0000)	0.316(0.000)
Broad money over GDP	-0.008(0.0116)	-0.002(0.1320)	-0.00065(0.470)
Initial GDP per capita (log)	-	-0.175(0.0088)	-0.182(0.000)
Secondary school enrolment (initial)	-	-0.339(0.2769)	-0.158(0.248)
Number of observations	107	102	102
R-squared/ Log likelihood	0.786	0.713	64.11483
F'/Wald-statistics''	35.392'(0.0000)	134.78'' (0.0000)	326.81'' (0.0000)
Hausman test	-	$\chi^2(9)= 24.24$ (0.0039)	-

Note p-value in parentheses. All regressions are run with constant. *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. For FGLS Log likelihood is reported

APPENDIX J

Table 5. Instruments for Investment Rate

Dependent Variable: Investment rate

Explanatory variable	Panel Regression(Random effect)	Panel Regression (Fixed-effects)
1	2	3
Inflation (log(1+ inflation rate))*	-0.034 (0.055)	-0.031(0.071)
Investment rate(log)*	0.72 (0.000)	0.469(0.000)
Broad money over GDP*	-0.000048 (0.962)	-0.003410.080)
Number of observations	112	112
R-squared/ Log likelihood	0.76	0.62
F/Wald-statistics	188.07 (0.0000)	F(3,87) =15.49(0.0000)
Hausman test	$\chi^2(3)$= 40.18 (0.0009)	

* lagged one period

Table 6. Instruments for Debt over GDP

Dependent Variable: Debt over GDP

Explanatory variable	Panel Regression(Random effect)	Panel Regression (Fixed-effects)
1	2	3
Debt over GDP*	0.759(0.000)	0.703 (0.000)
Openness Index	0.003 (0.007)	0.004 (0.060)
Fiscal balance	-0.024 (0.008)	-0.018 (0.135)
Number of observations	139	139
R-squared/ Log likelihood	0.847	0.841
F/Wald-statistics	188.07 (0.0000)	F(3,87) =15.49(0.0000)
Hausman test	$\chi^2(3)$= 4.23 (0.2375)	

* lagged one period

APPENDIX K

Table 7. Growth regression with quadratic specification (Instrumental Variable Regression)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed-effects IV)
1	2
Debt over GDP (log)	**-0.1703252 (0.075)**
Debt over GDP (log) squared	**-0.0479388 (0.148)**
Inflation (log(1+ inflation rate))	-0.7548968 (0.016)
Investment rate (log)	**-0.0831389 (0.432)**
Government consumption	0.023906 (0.555)
Fiscal balance	0.0163243 (0.013)
Population growth rate	- 2.6333342 (0.015)
De Melo index	0.2613361 (0.000)
Broad money over GDP	0.0002471 (0.853)
Number of observations	105
R-squared/ Log likelihood	0.778
F-statistics	201.38(0.0000)
Overidentified restrictions test	$\chi^2(6) = 5.3$ (0.51)
Wu-Hausman test	$\chi^2(9) = 6.44$ (0.58)

Note p-value in parentheses. All regressions are run with constant., * lninvrate, Debt to GDP are instrumented with Broad money lagged one period, log of investment rate lagged one period, inflation rate lagged one period, Debt over GDP indicator lagged one period, and openness index.

APPENDIX L

Table 8. Growth regressions with quadratic specification with investment rate, with time dummy (Panel for the whole sample)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)
1	2	3
Debt over GDP (log)	**-0.514 (0.002)**	**-0.161 (0.086)**
Debt over GDP (log) squared	**-0.147 (0.002)**	**-0.038 (0.158)**
Inflation (log(1+ inflation rate))	-0.899 (0.086)	-0.658 (0.044)
Investment rate (log)	**0.217 (0.091)**	**0.174 (0.051)**
Government consumption	0.017 (0.074)	0.006 (0.094)
Fiscal balance	0.014 (0.116)	0.022 (0.003)
Population growth rate	-1.719 (0.606)	-0.636 (0.820)
De Melo index	0.304 (0.001)	0.316 (0.000)
Broad money over GDP	-0.008 (0.014)	-0.0009 (0.427)
Initial GDP per capita (log)	-	-0.177 (0.000)
Secondary school enrolment (initial)	-	-0.211 (0.326)
1994	-	0.769 (0.160)
1995	-0.121 (0.092)	0.744 (0.180)
1996	-0.162 (0.046)	0.741 (0.176)
1997	-0.169 (0.045)	0.718 (0.192)
1998	-0.122 (0.157)	0.751 (0.165)
1999	-0.154 (0.072)	0.696 (0.200)
Number of observations	107	102
R-squared/ Log likelihood	0.672	0.637
F'/Wald-statistics"	10.53' (0.0000)	149.60" (0.0000)
Hausman test	-	$\chi^2(9)$= 58.25 (0.0000)

Note p-value in parentheses. All regressions are run with constant. *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. Note under fixed effect dummy on 1994 was dropped due to coleniarity.

APPENDIX M

Table 9. Growth regressions with quadratic specification without investment rate, without time dummy (Panel for the whole sample)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)
1	2	3
Debt over GDP (log)	**-0.392 (0.007)**	**-0.301 (0.002)**
Debt over GDP (log) squared	**-0.112 (0.007)**	**-0.079 (0.006)**
Inflation (log (1+inflation rate))	-1.052 (0.036)	-0.799 (0.021)
Investment rate (log)	-	-
Government consumption	0.020 (0.029)	0.009 (0.052)
Fiscal balance	0.014 (0.101)	0.024 (0.002)
Population growth rate	-2.02 (0.534)	0.301 (0.913)
De Melo index	0.218 (0.006)	0.298 (0.000)
Broad money over GDP	-0.009 (0.005)	-0.001 (0.340)
Initial GDP per capita (log)	-	-0.151 (0.014)
Secondary school enrolment (initial)	-	-0.091 (0.733)
Number of observations	107	107
R-squared/ Log likelihood	0.6325	0.5642
F'/Wald-statistics"	16.78' (0.0000)	127.36 (0.0000)
Hausman test	-	$\chi^2(8)=15.50$ (0.0501)

Note p-value in parentheses. All regressions are run with constant. *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction.

APPENDIX N

Table 10. Growth regressions with quadratic specification without investment rate, with time dummy (Panel for the whole sample)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)
1	2	3
Debt over GDP (log)	**-0.550 (0.001)**	**-0.262 (0.003)**
Debt over GDP (log) squared	**-0.161 (0.001)**	**-0.065 (0.017)**
Inflation (log(1+ inflation rate))	-1.115 (0.031)	-0.762 (0.025)
Investment rate (log)	-	-
Government consumption	0.0161 (0.098)	0.0071 (0.077)
Fiscal balance	0.0123 (0.177)	0.0249 (0.001)
Population growth rate	-1.341 (0.691)	1.384 (0.607)
De Melo index	0.259 (0.005)	0.310 (0.000)
Broad money over GDP	-0.0092 (0.006)	-0.0005 (0.677)
Initial GDP per capita (log)	-	-0.150(0.004)
Secondary school enrolment (initial)	-	-0.0763 (0.732)
1994	-	0.101 (0.824)
1995	-0.118(0.105)	0.0518 (0.910)
1996	-0.153 (0.063)	0.0666 (0.885)
1997	-0.157 (0.065)	0.0339 (0.941)
1998	-0.094 (0.271)	0.088 (0.847)
1999	-0.133 (0.121)	0.033 (0.942)
Number of observations	107	107
R-squared/ Log likelihood	0.6586	0.56
F'/Wald-statistics''	10.83' (0.0000)	175.20'' (0.0000)
Hausman test	-	$\chi^2(13)$= 39.81 (0.0001)

Note p-value in parentheses. All regressions are run with constant, *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. Note under fixed effect dummy on 1994 was dropped due to coleniarity.

APPENDIX O

Table 11. Growth regression with quadratic specification with investment rate without time dummy (Panel for the former USSR republics)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)	Panel Regression (Random effect)
1	2	3
Debt over GDP(log)	**-0.349(0.03)**	**-0.418 (0.002)**
Debt over GDP (log) squared	**-0.091(0.038)**	**-0.099 (0.008)**
Inflation (log(1+ inflation rate))	-1.126(0.172)	-0.874 (0.064)
Investment rate (log)	**0.096(0.526)**	**0.097 (0.390)**
Government consumption	0.011(0.296)	0.004 (0.418)
Fiscal balance	0.02(0.135)	0.028 (0.005)
Population growth rate	2.237(0.884)	3.549 (0.86)
De Melo index	0.228(0.035)	0.357 (0.000)
Broad money over GDP	-0.014 (0.083)	-0.004 (0.481)
Initial GDP per capita (log)	-	-0.00002 (0.575)
Secondary school enrolment (initial)	-	0.33 (0.530)
Number of observations	57	52
R-squared	0.577	0.7505
F/Wald-statistics	10.67 (0.0000)	120.32 (0.0000)
Hausman test	$\chi^2(8)= 6.89$ (0.5483)	

Note p-value in parentheses. All regressions are run with constant, *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction.

APPENDIX P

Table 12. Growth regression with quadratic specification with investment rate, with time dummy (Panel for the former USSR republics)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)	Panel Regression (Random effect)
1	2	3
Debt over GDP(log)	**-0.696(0.002)**	**-0.479 (0.001)**
Debt over GDP (log) squared	**-0.139(0.017)**	**-0.109 (0.005)**
Inflation (log(1+ inflation rate))	0.575(0.459)	-0.067 (0.896)
Investment rate (log)	**0.048(0.807)**	**0.032 (0.769)**
Government consumption	0.011(0.317)	0.003(0.590)
Fiscal balance	0.023 (0.038)	0.021 (0.029)
Population growth rate	3.015(0.820)	3.244108 (0.109)
De Melo index	0.242(0.033)	0.328 (0.000)
Broad money over GDP	-0.012(0.191)	-0.002 (0.591)
Initial GDP per capita (log)	-	-0.0000165 (0.544)
Secondary school enrolment (initial)	-	0.267 (0.579)
1994	-	-
1995	-0.0443 (0.713)	-0.108 (0.317)
1996	0.204 (0.209)	0.072 (0.566)
1997	0.397 (0.031)	0.21 (0.134)
1998	0.458 (0.019)	0.205 (0.135)
1999	0.471 (0.016)	0.168 (0.200)
Number of observations	57	52
R-squared	0.556	0.825
F/Wald-statistics	11.98 (0.0000)	164.79 (0.0000)
Hausman test	$\chi^2(13)$= 7.05 (0.89)	

Note p-value in parentheses. All regressions are run with constant, *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. . Note dummy on 1994 was dropped due to coleniarity.

APPENDIX Q

Table 13. Growth regression with quadratic specification without investment rate, without time dummy (Panel for the former USSR republics)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)	Panel Regression (Random effect)
1	2	3
Debt over GDP(log)	**-0.328 (0.044)**	**-0.460 (0.000)**
Debt over GDP (log) squared	**-0.086 (0.053)**	**-0.109 (0.002)**
Inflation (log(1+ inflation rate))	-1.228 (0.075)	-0.915 (0.050)
Investment rate (log)	-	-
Government consumption	0.0103 (0.328)	0.0048 (0.372)
Fiscal balance	0.0187 (0.137)	0.031 (0.000)
Population growth rate	3.215 (0.796)	10.55698 (0.016)
De Melo index	0.201 (0.023)	0.352 (0.000)
Broad money over GDP	-0.0165 (0.041)	-0.003 (0.541)
Initial GDP per capita (log)	-	-0.0000128 (0.646)
Secondary school enrolment (initial)	-	0.33 (0.529)
Number of observations	57	52
R-squared	0.48	0.75
F/Wald-statistics	12.24 (0.0000)	120.35 (0.0000)
Hausman test	$\chi^2(7) = 6.70$ (0.46)	

Note p-value in parentheses. All regressions are run with constant, *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction.

APPENDIX R

Table 14. Growth regression with quadratic specification without investment rate, with time dummy (Panel for the former USSR republics)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)	Panel Regression (Random effect)
1	2	3
Debt over GDP(log)	**-0.692 (0.002)**	**-0.500 (0.000)**
Debt over GDP (log) squared	**-0.138 (0.016)**	**-0.114 (0.001)**
Inflation (log(1+ inflation rate))	0.524 (0.476)	-0.068 (0.891)
Investment rate (log)	-	-
Government consumption	0.010 (0.322)	0.003(0.548)
Fiscal balance	0.022 (0.036)	0.022 (0.010)
Population growth rate	3.78 (0.766)	4.05 (0.35)
De Melo index	0.229 (0.020)	0.327 (0.000)
Broad money over GDP	-0.013 (0.045)	-0.0026 (0.587)
Initial GDP per capita (log)	-	-0.000015 (0.570)
Secondary school enrolment (initial)	-	0.263 (0.579)
1994	-	-
1995	-0.041 (0.723)	-0.113 (0.283)
1996	0.203 (0.204)	0.068 (0.580)
1997	0.398 (0.029)	0.205 (0.135)
1998	0.463 (0.016)	0.206 (0.128)
1999	0.475 (0.013)	0.171 (0.185)
Number of observations	57	52
R-squared	0.5585	0.8244
F/Wald-statistics	13.28 (0.0000)	164.79 (0.0000)
Hausman test	$\chi^2(13)$= 23.15 (0.0399)	

Note p-value in parentheses. All regressions are run with constant, *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. . Note dummy on 1994 was dropped due to coleniarity.

APPENDIX S

Table 15. Growth regressions with quintile specification, with time dummy (Panel for the whole sample)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)
1	2	3
First Quintile	0.045(0.776)	0.218 (0.034)
Second Quintile	-0.011 (0.939)	0.166 (0.033)
Third Quintile	-0.062 (0.675)	0.103 (0.186)
Fourth Quintile	-0.001 (0.990)	0.055 (0.545)
Inflation (log(1+ inflation rate))	-0.739 (0.184)	-0.698 (0.046)
Investment rate (log)	0.3(0.028)	0.059(0.526)
Government consumption	.023 (0.037)	0.002 (0.527)
Fiscal balance	0.021 (0.02)	0.012 (0.064)
Population growth rate	-1.99 (0.57)	4.48 (0.85)
De Melo index	0.32 (0.001)	0.335 (0.000)
Broad money over GDP	-.009 (0.008)	-0.001 (0.185)
Initial GDP per capita (log)	-	-0.150(0.004)
Secondary school enrolment (initial)	-	-0.0763 (0.732)
1994	-	0.101 (0.824)
1995	-0.051 (0.473)	-0.017 (0.826)
1996	-0.089 (0.274)	-0.045 (0.595)
1997	-0.085 (0.308)	-0.052 (0.545)
1998	-0.072 (0.413)	0.0006 (0.994)
1999	-0.106 (0.225)	-0.0669 (0.449)
Number of observations	107	107
R-squared/ Log likelihood	0.2789	0.55
F'/Wald-statistics"	7.68' (0.0000)	112.34" (0.0000)
Hausman test	-	$\chi^2(15) = 35.92$ (0.0018)

Note p-value in parentheses. All regressions are run with constant. *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. Note under fixed effect dummy on 1994 was dropped due to coleniarity.

APPENDIX T

Table 16. Growth regressions with quintile specification without investment rate, with time dummy (Panel for the whole sample)

Dependent Variable: growth of real GDP per capita

Explanatory variable	Panel Regression (Fixed effect)*	Panel Regression (Random effect GLS)
1	2	3
First Quintile	0.060(0.598)	0.207(0.038)
Second Quintile	0.011(0.926)	0.169(0.045)
Third Quintile	-0.023(0.852)	0.104(0.221)
Fourth Quintile	0.026(0.719)	0.091(0.315)
Inflation (log(1+ inflation rate))	-1.03 (0.063)	-.84 (0.022)
Investment rate (log)	-	-
Government consumption	0.02 (0.067)	0.003 (0.450)
Fiscal balance	0.02 (0.036)	0.018 (0.007)
Population growth rate	-1.4 (0.699)	3.64 (0.187)
De Melo index	0.264 (0.008)	0.336 (0.000)
Broad money over GDP	-0.01 (0.002)	-.0025 (0.061)
Initial GDP per capita (log)	-	-0.15 (0.004)
Secondary school enrolment (initial)	-	-0.076 (0.732)
1994	-	0.101 (0.824)
1995	-0.030 (0.678)	-0.028 (0.705)
1996	-0.058 (0.48)	-0.064 (0.42)
1997	-0.053 (0.526)	-0.075 (0.356)
1998	0.020 (0.81)	-0.021 (0.79)
1999	-0.062 (0.472)	-0.082 (0.314)
Number of observations	107	107
R-squared/ Log likelihood	0.213	0.54
F'/Wald-statistics"	7.43' (0.0000)	106.3" (0.0000)
Hausman test	-	$\chi^2(15) = 28.67$ (0.0116)

Note p-value in parentheses. All regressions are run with constant. *p-values are reported following White Heteroskedasticity-Consistent Standard Errors & Covariance correction. Note under fixed effect dummy on 1994 was dropped due to coleniarity.

APPENDIX U

Table 17. Correspondence of the 2002 Liberalization Index Components with EBRD Report Indicators

	EBRD Indicators 2002				
2002 LI Components	Price Liberalization and Competition	Trade and Foreign Exchange System	Large-scale Privatization	Small-scale Privatization	Banking Reform
I (internal prices)	**X**				
E (external markets)		**X**			
P (private sector entry)			**X**	**X**	**X**

Source: EBRD, Transition Report, 2002

APPENDIX V

Table 18. Tabulated main results from different growth specifications

Growth regressions for the whole sample					
Explanatory variable	Panel Regression (FE)	Panel Regression (FE IV)	Panel Regression (FE)*	Panel Regression (FE)^	Panel Regression (FE)^*
Debt over GDP (log)	**-0.371 (0.007)**	**-0.170 (0.075)**	**-0.514 (0.002)**	**-0.392 (0.007)**	**-0.550 (0.001)**
Debt over GDP (log) squared	**-0.101 (0.009)**	**-0.047 (0.082)**	**-0.147 (0.002)**	**-0.112 (0.007)**	**-0.161 (0.001)**
R-squared	0.786	0.778	0.672	0.6325	0.6586
Growth regressions for the former USSR countries					
	Panel Regression (RE)	Panel Regression (G2SLS RE IV)	Panel Regression (RE)*	Panel Regression (RE)^	Panel Regression (RE)^*
Debt over GDP (log)	**-0.418 (0.002)**	**-0.222 (0.087)**	**-0.479 (0.001)**	**-0.460 (0.000)**	**-0.500 (0.000)**
Debt over GDP (log) squared	**-0.099 (0.008)**	**-0.044 (0.09)**	**-0.109 (0.005)**	**-0.109 (0.002)**	**-0.114 (0.001)**
R-squared	0.7505	0.6991	0.825	0.75	0.8244

* With time dummy
^ Without investment rate

APPENDIX W

Consequences of change of debt on economic growth in transition countries using Ukrainian example.

From our estimated regression we can express growth as a function of the debt indicator in the following way: $G = \alpha - 0.37\ln D - 0.101(\ln D)^2$.

Here we should note that α expresses contemporaneous influence of all other specified variables when they are held constant. In order to derive the influence of debt indicator on growth when it changes by one unit we should differentiate growth with respect to debt indicator: $\frac{\partial G}{\partial D} = -\frac{0.37}{D} - \frac{0.202\ln D}{D}$.

Let us to show influence on the economic growth of doubling the Debt, under condition that initial Debt to GDP ratio approximately equal to 0.37[24] and the initial growth rate of real GDP per capita is 0.2%.

Firstly, we compute the change in growth after debt indicator was increased by one unit (which is equivalent to increase in the debt by the whole current GDP):

$$\frac{\partial G}{\partial D} = -\frac{0.37}{0.37} - \frac{0.202\ln 0.37}{0.37} = \text{-}0.457$$

Secondly, in order to find out the influence of doubling the debt, given the initial point on debt indicator is equal to 0.37, we just multiply -0.457 ($\left.\frac{\partial G}{\partial D}\right|_{\Delta D=1}$) by 0.37. Therefore, because of doubling the debt the economic growth rate will decrease approximately by 0.169 (in our example, from 0.2% to 0.031%).

[24] Our choice of 0.37 was made because the Ukraine Debt to GDP ratio was approximately equal to 0.37 in 1999 year.

APPENDIX X

Calculation of confidence interval (for nonlinear function)

Let $G = \alpha + \beta_1 LnD + \beta_2 (LnD)^2$ then maximizing G with respect to D we will get the following relationship: $D^* = \exp(-\frac{\beta_1}{2*\beta_2})$.

As our optimum of debt to GDP ratio is a nonlinear function of $\beta_1 and \beta_2$:

$D^* = \exp(-\frac{\beta_1}{2*\beta_2})$, it means that in order to find variance of D we should employ the following formula :

$$V(D^*) = \begin{pmatrix} \frac{\partial D^*}{\partial \beta_1} & \frac{\partial D^*}{\partial \beta_2} \end{pmatrix} \begin{pmatrix} V(\beta_1) & COV(\beta_1 \beta_2) \\ COV(\beta_1 \beta_2) & V(\beta_2) \end{pmatrix} \begin{pmatrix} \frac{\partial D^*}{\partial \beta_1} \\ \frac{\partial D^*}{\partial \beta_2} \end{pmatrix}$$

$$\text{where } \frac{\partial D^*}{\partial \beta_1} = \left[\exp\left(-\frac{\beta_1}{2*\beta_2} \right) \right] \left(-\frac{1}{2*\beta_2} \right)$$

$$\text{and } \frac{\partial D^*}{\partial \beta_2} = \left[\exp\left(-\frac{\beta_1}{2*\beta_2} \right) \right] \left(\frac{\beta_1}{2*\beta_2} \right)$$

Knowing the variance of the D* variable we can find out the confidence interval of 95% just in the following way: $D^* \pm 2 * \sqrt{V(D^*)}$

To find out the 95% confidence interval for the range of growth maximizing debt to GDP ratio we should calculate all of the confidence intervals for our point estimates of optimum level of debt over GDP ratio. Then we should chose the maximum and minimum values of all confidence intervals, which will be end points for our confidence interval of optimum level of debt to GDP ratio.

Confidence interval for negative marginal impact of debt on growth can be and was found in the same manner.